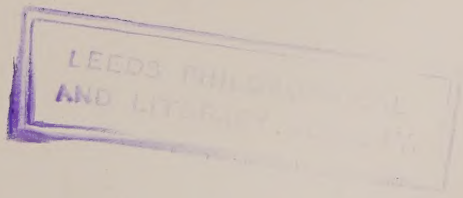
MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVI. FEBRUARY 14, 1896. No. 5



A. A. COMMON, LL.D., F.R.S., President, in the Chair.

Cyril E. Ashford, M.A., The School, Harrow ;
Frank Arthur Bellamy, F.R.Met.Soc., University Observatory, and 4 St. John's Road, Oxford ;
Thomas Folkes Claxton, Royal Alfred Observatory, Mauritius ;
Philip H. Cowell, B.A., Trinity College, Cambridge ;
Robert Fermor Rendell, B.A., The Glen, Blackheath Hill, S.E. ;
George Albert Smith, St. Ann's Gardens, Brighton ; and
Charles Albert Taylor, 33 Argyle Street, Argyle Square,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

William Anderson, Gentleman, Ballee House, Ballymena, Co. Antrim, Ireland (proposed by A. A. Rambaut) ;
Thomas Frederick Furber, Chief Computer, Trigonometrical Survey of New South Wales, Department of Lands, Sydney, N.S. Wales, Australia (proposed by R. T. A. Innes) ;
Frank L. Grant, M.A., 58 Kelvington Street, Glasgow (proposed by L. Becker) ;
Edward Ayearst Reeves, Royal Geographical Society, Savile Row, W., and 24 Clyde Road, Wallington, Surrey (proposed by John Coles) ;
George Frederick Herbert Smith, B.A., Scholar of New College, Oxford (proposed by H. H. Turner) ; and
T. M. Teed, C.E., F.R.C.S., 188 Camberwell Grove, Denmark Hill, S.E. (proposed by John Coles).

Report of the Council to the Seventy-sixth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Mathematical Society	Total Fellows	Associates	Patron	Grand Total
December 31, 1894	247	392	1	640	48	1	689
Since elected	+4	+28	...	...	...	...	...
Deceased	−8	− 6	−1	...	−2	...	...
Resigned	...	−11	...	...	...	...	...
Removals	+2	− 2	...	...	...	...	...
Expelled	...	−10	...	...	...	...	...
December 31, 1895	245	391	...	636	46	1	683

Mr. Knobel's Account as Treasurer of the Royal

RECEIPTS.

	£ s. d.	£ s. d.
Balances, 1895 January 1:—		
At Bankers', as per Pass Book	391 15 1	
Outstanding Cheque	23 2 0	
In hand of Assistant Secretary on account of Turnor and Horrox Fund	13 8 7	
In hand of Assistant Secretary on Petty Cash Account	15 0 2	
		443 5 10
Dividends on £13,200 Consols, 2¾ per cent. ...	350 18 4	
„ on £900 New 2½-per-cent. Stock ...	21 15 0	
„ on £1,250 Metropolitan 3-per-cent. Stock	36 5 0	
		408 18 4
Received on account of Subscriptions:—		
Arrears	174 6 0	
Annual Contributions for 1895	585 18 0	
„ „ 1896	10 10 0	
Admission Fees	60 18 0	
First Contributions	40 19 0	
		872 11 0
Composition Fees		126 0 0
Sales of Publications:—		
At Williams & Norgate's, 1894	7 3 7	
At Society's Rooms, 1895	46 6 9	
Sale of Photographs	21 16 0	
		75 6 4
Income Tax refunded by Commissioners of Inland Revenue		13 13 7

Audited and found correct, 1896 January 8.

H. P. Hollis,
Sidney Waters,
D. Smart.

£1,939 15 1

Astronomical Society, from 1895 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
„ „ for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	7	16	6			
				10	9	0
Printing, &c., *Monthly Notices*	405	9	6			
„ Miscellaneous	40	4	0			
Plates (Woodbury type)	2	8	0			
				448	1	6
Turnor and Horrox Fund: Purchases for Library	27	8	3			
Binding Books in Library	31	0	6			
Copying Photographs	4	16	6			
				63	5	3
Grant to Photographic Committee				20	0	0
Clerk's Wages	46	11	0			
Postage and Telegrams	73	5	7			
Carriage of Parcels	2	9	5			
Stationery and Office Expenses	8	6	0			
				130	12	0
Expenses of Meetings	20	0	0			
Lantern Expenses	4	14	1			
				24	14	1
House Expenses	61	10	7			
Coals and Gas	72	2	0			
Electric Light Expenses	7	0	11			
Rental of Wire for Time Signal, &c.	5	6	0			
Sundry Fittings and Repairs...	15	8	7			
Sundries	6	8	3			
				167	16	4
Decorating Society's Rooms, Trollope & Sons (on account)	250	0	0			
Carpets, &c., Maple & Co.	50	9	8			
Pedestals for Busts, &c., Macdonald & Co. ...	26	17	6			
Fittings in Upper Library, Brown & Blomfield ...	86	10	0			
Furniture in Office, &c.	7	8	0			
				421	5	2
Lee and Janson Fund Grants				4	0	0
Cheque Book and Deductions on Cheques				0	10	1
Balances, 1895 December 31:—						
At Bankers', as per Pass Book	286	12	10			
Outstanding Cheques	24	6	6			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	14	8	4			
In hand of Assistant Secretary on Petty Cash Account	3	3	0			
In hand of Assistant Secretary on account of Sales of Photographs	20	11	0			
				349	1	8
				£1,939	15	1

Report of the Auditors.

We have examined the Treasurer's accounts for the year 1895, and have found and certified the same to be correct. The cash in hand on 1895 December 31, including the balance at the bankers', &c., amounted to £349 1*s.* 8*d.*

The funded property of the Society is the same as at the end of the previous year.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

The Auditors suggest that it is desirable that a notice be distributed with the February number of the *Monthly Notices*, pointing out that the annual subscription for the forthcoming year is then due.

With reference to the Composition Fees mentioned in the accounts, the Auditors suggest that the time has come when Section V. of the Bye-laws of the Society, which relate to payment of subscriptions, should be revised. They consider that twenty guineas paid on entrance is not now fairly proportionate to an annual subscription of two guineas, and they think a scheme should be devised by which subscribers might be allowed to compound at any later time on payment of a reduced sum—the reduction being in proportion to the amount of previous subscriptions paid.

(Signed) H. P. Hollis,
Sidney Waters,
David Smart.

1896 *January* 8.

Trust Funds.

The Turnor Fund: A sum of £450 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £100 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £323 16*s.* 6*d.* 2¾-per-cent. Consols, the interest to be given by the Council to the widow or orphan of any deceased Fellow or Associate of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £300 2¾-per-cent. Consols, the interest to be given in medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1896 January 1.

	£	s.	d.	£	s.	d.
Balances, 1895 December 31:—						
At Bankers', as per Pass Book	286	12	10			
Outstanding cheques	24	6	6			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	14	8	4			
In hand of Assistant Secretary on Petty Cash Account	3	3	0			
In hand of Assistant Secretary on account of Sales of Photographs	20	11	0			
				349	1	8
Due on account of Subscriptions:—						
2 Contributions of 4 years' standing... ...	16	16	0			
6 „ 3 „	37	16	0			
32 „ 2 „	134	8	0			
67 „ 1 „	140	14	0			
6 Admission Fees, &c....	18	18	0			
	348	12	0			
Less 5 Contributions paid in advance ...	10	10	0			
				338	2	0
Due from Messrs. Williams & Norgate for sales of Publications during 1895				20	13	8

£13,200 2¾-per-cent. Consols, including the Lee and Janson Fund, the Turnor and Horrox Fund, and the Jackson-Gwilt Fund.

£900 New 2½-per-cent. Consols.

£1,250 Metropolitan 3-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, and Instruments; Furniture, &c.

Unsold Publications of the Society.

1 Gold Medal.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	7	...	XXX.	153	...
I. Part 2	42	...	XXXI.	136	...
II. Part 1	51	3	XXXII.	148	...
II. Part 2	17	3	XXXIII.	157	...
III. Part 1	65	1	XXXIV.	159	2
III. Part 2	83	1	XXXV.	105	3
IV. Part 1	78	3	XXXVI.	188	8
IV. Part 2	90	3	XXXVII. Part 1	334	7
V.	101	3	XXXVII. Part 2	279	8
VI.	119	6	XXXVIII.	264	1
VII.	141	3	XXXIX. Part 1	230	3
VIII.	125	3	XXXIX. Part 2	236	3
IX.	132	3	XL.	253	1
X.	144	...	XLI.	402	...
XI.	151	...	XLII.	227	3
XII.	157	...	XLIII.	228	...
XIII.	155	...	XLIV.	208	1
XIV.	363	...	XLV.	242	...
XV.	136	...	XLVI.	222	3
XVI.	161	1	XLVII. Part 1	3	...
XVII.	145	1	XLVII. Part 2	18	...
XVIII.	137	1	XLVII. Part 3	2	...
XIX.	147	...	XLVII. Part 4	10	...
XX.	136	1	XLVII. Part 5	8	...
XXI. Part 1	310	...	XLVII. Part 6	9	...
XXI. Part 2	98	...	XLVII.	196	1
XXI. 1 & 2 (together)	58	...	XLVIII. Pt. 1	245	1
XXII.	160	1	XLVIII. Pt. 2	239	1
XXIII.	144	...	XLIX. Part 1	389	5
XXIV.	151	1	XLIX. Part 2	270	1
XXV.	161	...	L.	271	...
XXVI.	167	1	LI.	400	6
XXVII.	419	1	Index to *Memoirs*	628	3
XXVIII.	378	...			
XXIX.	400	...			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	57	...	XXIX.	51	...
II.	59	...	XXX.	63	2
III.	...	...	XXXI.	92	...
IV.	...	...	XXXII.	111	5
V.	...	...	XXXIII.	94	...
VI.	43	...	XXXIV.	70	1
VII.	2	...	XXXV.	54	...
VIII.	153	2	XXXVI.	27	1
IX.	24	3	XXXVII.	34	3
X.	172	1	XXXVIII.	97	2
XI.	184	...	XXXIX.	95	...
XII.	106	2	XL.	106	3
XIII.	177	2	XLI.	106	5
XIV.	176	3	XLII.	115	1
XV.	168	2	XLIII.	112	2
XVI.	154	1	XLIV.	115	2
XVII.	167	1	XLV.	117	1
XVIII.	242	...	XLVI.	112	...
XIX.	52	...	XLVII.	130	2
XX.	31	...	XLVIII.	122	1
XXI.	16	...	XLIX.	116	9
XXII.	30	...	L.	118	11
XXIII.	17	...	LI.	119	9
XXIV.	22	...	LII.	117	12
XXV.	14	...	LIII.	119	15
XXVI.	10	1	LIV.	119	19
XXVII.	3	...	LV.	135	9
XXVIII.	70	...	Index ...	556	5
Library Catalogue				557	2

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LV., no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver ; reading microscopes, both for altitude and azimuth ; cross and siding levels ; magnetic needle ; plumb-line ; portable clamping foot and tripod stand.

No. 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.

„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Ys for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

No. 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.
„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.
„ 47. (21) Box sextant ; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen ; a strongly fitted brass box with heavy magnet ; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton ; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices ; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough ; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches ; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square ; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms ; two Babinet's compensators ; two double-image prisms ; three Savarts ; one positive eyepiece, with Nicol's prism ; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.

No. 83. An early non-achromatic telescope, of about 3 feet focal length in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch case, by Professor Chevalier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. } Two old sun-dials.
„ 118. }
„ 119. Specimens of diffraction gratings, by Prof. W. A Rogers.

No. 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant, by Troughton.
„ 131. Double box sextant, by Cary.

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for spectroscope.
2 Abney lenses used in photographing the corona.
2 Dallmeyer negative enlarging lenses.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 16. The *Wollaston* telescope, to Mr. R. Inwards.
„ 22. The *Matthew* equatorial, to Mr. J. Brett.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 27. (1) 30-inch transit and stand, to Mr. B. T. Moore.
„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
„ „ Wire micrometer (No. 1), to Mr. C. Thwaites.
„ 30. (4) $3\frac{1}{4}$-inch equatorial, to Mr. E. B. Powell.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. F. J. Wardale.
„ 47. (21) Box sextant and horizon, to Mr. C. H. Johns.
„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.
„ 69. (43) Telescope with rock-crystal object glass, to Dr. W. Huggins.
„ 72. (*a*) Polarimeter, to Dr. A. M. W. Downing.
„ 72. (*c*) Polarimeter, to Professor C. M. Smith.
„ 78. $9\frac{1}{3}$-inch reflector and stand, to Mr. Maxwell Hall.
„ 85. Double image micrometer, to Mr. B. T. Moore.
„ 99. 12-inch transit with portable stand, to Mr. H. T. Vivian.
„ 119. Diffraction gratings, to Mr. B. T. Moore.
„ 120. 6-prism spectroscope, to Mr. C. Thwaites.

No. 123. 6-inch telescope, by Grubb (object-glass only) to Mr. W. E. Wilson.
„ 125. 6-inch refractor by Simms, to Dr. A. A. Common.
„ 126. $3\frac{1}{2}$-inch portable refractor, by Tulley, to Mr. H. Sadler.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Mr. S. C. Chandler, for his discussion of the Variation of Latitude, his work on Variable Stars, and other astronomical investigations.

Publications of the Society.

Volume LI. of the *Memoirs* has been published during the past year, containing the following papers :—

"On the investigation of the division errors of the scales of the Cape Repsold Measuring Apparatus, and the determination of the errors of the Oxford *réseau*." By David Gill.

"Spectrum of *Nova Aurigæ*." By Rev. W. Sidgreaves.

"Physical observations of *Mars*, made at the Allegheny Observatory in 1892." By J. E. Keeler.

"Comparison of the Greenwich Ten-Year Catalogue (1880) with the Cape Catalogue (1880)." By H. H. Turner and H. P. Hollis.

"An experiment with a $12\frac{1}{2}$-inch refractor, whereby the light lost through the secondary spectrum is separated out and rendered approximately measurable." By H. Dennis Taylor.

"On the R—D discordance." By H. H. Turner and W. G. Thackeray.

"On the rotation and mechanical state of the Sun." By R. A. Sampson.

"Index Catalogue of Nebulæ found in the years 1888–94, with notes and corrections to the New General Catalogue." By J. L. E. Dreyer.

"Double Star Observations, 1892–94." By W. H. Maw.

"A determination of the constant of nutation from Greenwich meridian observations of *Polaris*, 1836–93." By W. G. Thackeray.

"Further measures of double stars, made at the Temple Observatory, Rugby, during the years 1890–95." By G. M. Seabroke and H. P. Highton.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :

Fellows :—Isaac Brown.
James Campbell.
Arthur Cayley.
Sir James Cockle.
E. J. Collingwood.
Richard Dunkin.
Sir C. C. Graham.
J. R. Hind.
F. R. Hughes.
A. L. Kaye.
A. J. Melhuish.
E. H. Nightingale.
John Nottingham.
O. A. L. Pihl.
Alfred White.

Associates :—Gustav Spörer.
Friedrich Tietjen.

There has always been a little ambiguity connected with these lists of deceased Fellows ; the names of those who have died between December 31 and the date of the Annual Meeting being generally included in this list, but omitted in the count given in the table at the beginning of this Report ; and in these cases, too, it is often difficult to obtain the particulars in time for the Report. Thus the names of Professor Cayley and Sir James Cockle were included in the list of the last Report, and a notice of Sir James Cockle was given, but not of Professor Cayley.

Isaac Brown was born at Amwellbury, a farm near Ware, in Hertfordshire, in the year 1803. Throughout his long life he was a member of the Society of Friends. His vocation was teaching —first in his own private school at Hitchin in 1829, which was removed to Dorking in 1845, and in 1848 as Principal of the Friends' Flounder's Institute at Ackworth, in Yorkshire, a post which he retained for twenty-two years.

In 1870, on resigning this appointment, he settled for the remainder of his life at Brantholme, Kendal.

He was twice married, and had six children by his first wife, four of whom survive him.

Highly cultured, refined and scholarly in all his tastes, and with a mind ever reaching after things high and heavenly, it was little wonder that the bent of his purely scientific pursuits turned strongly towards astronomy, a science which, in all its branches, retained its charm for him and exercised his unimpaired intellectual faculties unto the end.

Isaac Brown was elected a Fellow of the Royal Astronomical Society in 1851. While at the Flounder's Institute he was in the habit of using a $4\frac{1}{2}$-inch refractor by Cooke & Sons, also a transit instrument for obtaining correct astronomical time. As years went on every new discovery was to him a subject of interest and delight, and but for his advanced age, a fact not always easy to realise, he would probably have become a member of the British Astronomical Association, a society in the establishment and progress of which he took the deepest interest, hailing with especial satisfaction its admission of ladies to equal honours.

Very recent letters exist in which, in his peculiarly fine and clear handwriting, he dilated on the wonderful discoveries of modern astronomy, as much in touch with the times he lived in as any of the younger votaries of science.

Isaac Brown was for forty-five years a Fellow of the Royal Meteorological Society, and also in earlier life devoted considerable time to botanical research.

He died on 1895 November 3.

[For the above particulars the Council is indebted to Miss E. Brown.]

James Campbell was fourth child and only surviving son of Major-General Sir James Campbell, K.C.B., of Sanda, Argyllshire, and his wife the Lady Dorothea Louisa Cuffe, daughter of the Earl of Desart.

He was born 1822 October 30, at Mount Lavinia, in Ceylon, of which his father was then Governor. Sir James was also Governor of Grenada afterwards. Before this he had served with distinction throughout the Peninsular Campaign in command of the 94th Regiment. Owing to his position and occupation the family were constantly travelling, and James was educated abroad, chiefly in France. He showed his strong taste for study while very young, and took the degree of Bachelier-ès-Arts in Paris at an unusually early age. Later on, in London, he studied law, and was called to the Bar (Middle Temple), but he never practised.

When Vice-Admiral Sir C. Napier took his fleet in 1854 to the Baltic, Mr. Campbell accompanied it in his yacht the *Esmeralda*, and was present at the bombardment and capture of Bomarsund. It was during this time that his vessel was stationed

as a kind of light-ship near the "Bell Rock" to warn others from this dangerous spot. Early in the Italian War of Independence Mr. Campbell enlisted in the Foreign Legion, and served as aide-de-camp to Garibaldi, whom he knew and greatly admired. When the latter came to London Mr. Campbell saw him frequently, and was at the dinner given to the distinguished visitor at the Reform Club.

Soon after his return from Italy, in 1860, Mr. Campbell met and married Miss Ellen Cottingham. They had only one child, a daughter. His wife's health being delicate, he left his residence in Kilburn about four years after his marriage, and went to live in the country. Barnet, in Hertfordshire, was the place finally settled on, and there he bought Arkley House, where he lived many years.

In 1865 Mr. Campbell was a candidate for Chester, but was unsuccessful. Political life was not altogether to his taste, and he soon relinquished all attempts in that direction.

What he most loved was science of every kind, but particularly the science of mathematics. He soon became so absorbed by astronomy that in 1877–78 he built the Arkley Observatory, and devoted himself to astronomical matters. In conjunction with Mr. Neison (now Mr. Neville-Nevill, of the Durban Observatory, Natal) he worked for several years at the Lunar Theory. The first joint paper by Campbell and Neison appears in *Monthly Notices*, vol. xl. pp. 386–411 and 441–472, and is entitled "On the Determination of the Solar Parallax by means of the Parallactic Inequality in the Motion of the Moon." After discussing at length previous observations available for this purpose, the authors conclude that the chief systematic errors affecting these observations can be avoided by observing transits of a small crater on the Moon instead of the limb, and declare their intention of making a series of observations on the crater Murchison A. This work was commenced at the Arkley Observatory in 1879 April, and in that year twenty-one observations were obtained. In 1880 fifty-three were added, in 1881 another fifty-three, and others (not specified) in 1882, the report in 1883 February being the last received by this Society from the Arkley Observatory.

Since his removal to Natal, Mr. Neison [Nevill] has carried on these observations and the work of reducing them, and in the report of the Natal Observatory for 1892 February he writes: "The final touches are also being put to the discussion of the observations of the position of the lunar crater Murchison A, made at the Arkley Observatory in the years 1879–1884, and at the Natal Observatory during the years 1883–1886."

In 1885, for various reasons, Mr. Campbell broke up his work and left Arkley. Shortly before he left he began to give much time and study to mechanical inventions. Among other patents taken out by him was a very ingenious ship's log, which showed on a dial on board the exact speed of the ship from time to time.

From Arkley he went to live at Bush Hill Park, Enfield, and in 1888 he again removed, to Strawberry Hill, Twickenham, to be near his daughter and her husband. There in 1892 June his wife died. Mr. Campbell felt his loss acutely, and never entirely recovered either health or spirits, though up to this time he had been a man of robust constitution, singularly simple in tastes and habits. In 1894 December he caught a severe cold, which ended in influenza and severe bronchitis, and after a painful illness of a few days he passed away on December 11 in his seventy-third year.

During his latter years Mr. Campbell bore many severe trials with wonderful patience and fortitude, and these, instead of souring or embittering, seemed to show up more strongly the sterling qualities of his mind and nature. To the last he retained his devotion to learning and science and his wonderful love for animals, especially dogs. For over forty years he possessed a very fine breed of Newfoundlands. Several generations had been his loved companions; he was never without one or two wherever he went. "Mr. Campbell's great dogs" were as well known as himself.

[For many of these particulars the Council is indebted to Mr. Campbell's daughter, Mrs. Campbell-Heap.]

Arthur Cayley was the second son of Henry Cayley, a Russia merchant settled at St. Petersburg. He was born at Richmond, Surrey, on 1821 August 16, during a short visit of his parents to this country. The family returned permanently to England in 1829, and after a time fixed their residence at Blackheath, Kent. He was sent to a private school at that place, kept by the Rev. G. B. F. Potticary, and at the age of fourteen he went to King's College School, London. He came up to Trinity College, Cambridge, in 1838, and graduated in 1842 as Senior Wrangler and First Smith's Prizeman. It has often been the subject of remark that four such distinguished mathematicians as Leslie Ellis, Stokes, Cayley, and Adams should have been senior wranglers in four successive years.

Cayley was elected Fellow of his college in the year in which he took his degree, and was assistant tutor for about three years. As he did not take holy orders his fellowship was only tenable for a limited term, and it was necessary for him to select a profession. He chose the Bar, and about 1847 he became a pupil of the eminent conveyancer, Mr. Christie. He was called to the Bar in 1849, and during the time that he practised was always supplied by Mr. Christie with as much conveyancing work as he was willing to undertake.

As an undergraduate he had shown very marked mathematical ability, and had already published two or three papers in the *Cambridge Mathematical Journal* at the time of the examination for his degree. The *viva voce* part of the examination still existed then, and Mr. Gaskin, the Senior Moderator, told him that he was acquainted with his papers and need ask

him no questions. During the time in which he resided at Cambridge after his degree, and while at the Bar, he was incessantly occupied with mathematical investigations, and it was during this period of his life that some of his finest work was produced.

Certain lectureships on algebra, tenable for ten years, in each of the colleges at Cambridge were founded by Lady Sadler at the beginning of the last century, and had existed from 1710 till 1860. In the latter year a statute was sanctioned which enacted that after that date no more lecturers were to be appointed, and that when so many vacancies had occurred that not more than one-half of the net income of the foundation was required for the payment of the remaining lecturers a Sadlerian professorship of pure mathematics was to be established. The requisite number of vacancies occurred in 1863, and Cayley was elected the first Sadlerian professor. He willingly gave up the prospect of great legal eminence in order to devote his whole time and thought to his favourite subject, and at once returned to Cambridge. Perhaps no professorship was ever founded more opportunely.

There is scarcely any department in the whole range of mathematical literature which was outside the field of Cayley's work, and even among the minor subdivisions of mathematics it is difficult to think of a subject which did not claim his attention at some time in his life. He was a most prolific writer, and probably equalled Euler in versatility and facility of production. The regions most extended by his labours were, perhaps, Algebra, Analytical Geometry, and the Integral Calculus, but he also contributed largely to the Theory of Numbers. About 1856, when he had already published more than 150 papers on subjects relating to pure mathematics, he seems to have been attracted to dynamics and elliptic motion, for in that year he contributed a paper on the "Theory of Elliptic Motion" to the *Philosophical Magazine*, and his report on the "Recent Progress of Theoretical Dynamics" appeared in the *Report of the British Association* for 1857. He also wrote a paper on "Hansen's Lunar Theory," in the *Quarterly Journal of Mathematics* for 1857, and (in the same volume) a note on "Jacobi's Formulæ for Disturbed Motion in an Elliptic Orbit." He was elected a Fellow of our Society on 1857 July 10, and during the next few years communicated several elaborate memoirs relating to the development of the Disturbing Function, which were printed in vols. xxvii.–xxxi. of the *Memoirs*. When Adams's value of the secular acceleration of the Moon's mean motion was so strenuously controverted by Pontécoulant and others, Cayley undertook an independent calculation of the coefficient of the term in dispute, his result confirming Adams's value. This paper was printed *in extenso* in the *Monthly Notices* for 1862. Cayley's subsequent communications to the Society were numerous; but, with the exception of the papers relating to Delaunay's lunar theory, they may be said to have related chiefly to mathematical questions.

that fell within the domain of astronomy rather than to astronomy itself. For example, the elaborate memoirs on the determination of the orbit of a planet from three observations, and on the geodesic lines on an ellipsoid, contain little that concerns even a mathematical astronomer, unless he were also interested in pure mathematics. It may here be mentioned that projections and graphical methods always had a special attractiveness for Cayley; his inclination towards these subjects is shown in several of his papers published by the Society.

In 1859 December he became the editor of the publications of the Society, in succession to Mr. Grant, who had been appointed Professor of Astronomy at Glasgow. The *Monthly Notices* and *Memoirs* were edited by him continuously from that time until 1882, except during the two years of his Presidency, 1872–74, when the editorship was undertaken by Mr. Proctor. Cayley was a Member of Council from 1858 until 1893, and during nearly the whole of that period he was a regular attendant at the meetings.

The duties of the Sadlerian professor were "to explain and teach the principles of pure mathematics and to apply himself to the advancement of that science." Cayley delivered one course of lectures in the Michaelmas term of each year until the professorship was placed under the new statutes in 1886, after which he lectured in the Lent term also. The teaching work attached to the professorship was therefore very small, and he was free to devote his whole energies to the advance of his subject. How splendidly he availed himself of his opportunities is shown by his writings, which have influenced every branch of mathematics. In mere extent they are very considerable, exceeding 800 in number.

It is difficult to do adequate justice to Cayley's merits as a mathematician, so great and varied were his powers and so wide the range of subjects to which they were applied. It is, perhaps, as one of the principal founders of the modern higher algebra that his name is best known. It is forty years since these notable researches of Cayley and Sylvester followed each other in such quick succession. Salmon also bore a part, and it was by his well-known treatise that the newly-discovered subject was rendered available to students. With the exception of quaternions, this is the only branch of mathematics which this country can claim the honour of having originated and developed. Cayley's great memoir on elliptic functions, in which they were derived from the doubly periodic products, appeared as long ago as 1845. He also made other important contributions to this subject, being especially interested in the algebraical theory of transformation and the modular equations. The theories of curves and surfaces were greatly extended by his labours. Reference should also be made to the geometry of n dimensions, which frequently occupied his attention at all times in his life. The only separate book published by him was a treatise on *Elliptic Functions* which appeared in 1876.

The republication of Cayley's collected papers was undertaken by the Cambridge University Press in 1889, and seven volumes, containing 485 papers, had been issued under his own editorship at the time of his death. Since then two additional volumes, carrying the papers down to 1877, have been issued under the editorship of Professor Forsyth. The number of papers contained in the nine volumes is 629, and it is announced that the completed works will probably extend to thirteen volumes. Some idea of the mass of work published by Cayley may be obtained when it is stated that each volume is a quarto of 600 or more closely printed pages.

With respect to the character of Cayley's work, it is scarcely possible to exaggerate his immense grasp over the analytical processes. As an algebraist it is probable that he has never been surpassed. He seemed able to apply algebraical methods to every kind of subject with masterly success, and to possess the gift of discovering the right "handle" wherewith to take hold of a subject, so to speak. An extraordinary command over the management of symbols, and a penetrating insight into the truths that underlay the formulæ, were perhaps the most conspicuous of the qualities which enabled him to do lasting work in every branch of mathematics. In preparing his work for publication Cayley seemed to care only for the substance, attaching but little importance to elegance of form or simplicity of development. He made no attempt to exhibit his results in their most attractive form; in fact, when he had been occupied on a subject for some time, he would frequently put together the work he had done pretty much as it stood, and send it for publication. He always printed his investigations as he did them, and at no time were there any considerable accumulations. We owe it to this habit that he has left no arrears of unfinished work.

His power of entering into the researches of others was hardly less remarkable than his wonderful capacity for original work. By merely "dipping into" a difficult foreign memoir he was able to seize the meanings of the symbols and comprehend the principal results without reading the investigation itself. The theorems which he had thus mastered he would frequently prove by a method of his own (generally algebraical), almost always carrying the investigation further. This gift of almost instantaneously grasping and seeing in a new light the results of others contributed in no slight degree to increase the great reputation his writings had won him on the Continent. As regards the nature of his own work, he was essentially a great explorer; he loved to explore anywhere, and he was always tempted by any newly discovered territory. This universality of his tastes, and his great fertility, are very remarkable characteristics. He had no liking for the philosophy of mathematics, and did not care much to contemplate existing knowledge, or dwell upon what he had accomplished himself. Each new result would seem to have presented itself to him principally as a fresh point of departure for

new investigations. He was fond of making *résumés* of work done on a special subject, but his object generally was to clear the ground for future research.

Cayley's lectures almost invariably related to a subject upon which he was then engaged, and the lectures themselves sometimes contained the results of work done since the preceding lecture. For example, the paper already referred to, on the determination of the orbit of a planet from three observations, formed the subject of one of his courses of lectures before it was completed and presented to our Society. He did not give the same course of lectures twice, nor did he ever prepare a course of lectures distinct from work that was occupying his attention at the time. The general expression of his views on any branch of mathematics and his mode of work were interesting ; but he had not the art of teaching, nor was the matter or arrangement of his lectures suitable for those who were previously unacquainted with the subject. The attendance was small, and the lectures did not form part of the ordinary course of mathematical study in the university. He was a good correspondent, and to letters asking for information on mathematical questions he always returned full and prompt replies. A vast number of mathematical papers submitted to scientific societies were referred to him ; and in all such cases he was an admirable referee. He had a clear and definite idea of the standard of excellence—not an unduly high one—that should be maintained, and his reports were always valuable and practical.

After 1863 he spent the remainder of his life in Cambridge, principally occupied by mathematical research. He undertook, however, a very considerable amount of voluntary work for bodies with which he was connected. He freely placed his time, legal knowledge, and skill at the disposal of his university and college, and of the scientific societies to which he belonged. The present statutes of Trinity College, Cambridge, were principally drafted by him, and during the years in which he was one of the members of the Council of the Senate he undertook a good deal of work of the same class for the university. One of the last services of this kind which he performed was the drafting of the regulations of the Isaac Newton studentships, founded by Mr. McClean in 1890. On councils, or committees, or syndicates in the university he was always one of the most valued members. He spoke only when he had something of importance to say, and was always listened to with respect. He was perfectly fair-minded, and possessed a sound judgment and a temper that could not be ruffled. Though conservative in most matters, he was free from general political bias. At the elections to the Council of the Senate at Cambridge he was usually nominated by both parties, and in other cases, where there was a conflict of opinion he was invariably supported by all sides. He was retiring in disposition and very shy in manner, though less so in the latter part of his life. He was singularly unfitted for party strife in any form, and was

always unwilling to concern himself with the conduct or motives of others. His character, however, was a strong one, and he never allowed himself to swerve from what he believed to be his duty. He was businesslike in the affairs of ordinary life, and everything that fell to him to do was well and punctually done. He took a special interest in matters relating to finance, and only a few months before his death published a pamphlet on book-keeping. He steadily supported the movement for the promotion of the higher education of women from the first, and for some years was Chairman of the Council of Newnham College.

He was a good linguist, and was an eager reader of fiction all through his life. He was also interested in painting and architecture, and derived much comfort from his acquaintance with these subjects in his long and wearisome illness. He was very fond of walking up to the last few years of his life, and took an especial delight in mountain scenery. Although not social in the ordinary sense of the word, he was not a recluse, but liked the society of his friends, who were always welcome to his house.

He was President of the London Mathematical Society, 1868–70, of the Cambridge Philosophical Society, 1869–71, and of the British Association at the Southport meeting in 1883, on which occasion the subject of his presidential address was the progress of pure mathematics. When he was President of our Society in 1874 he delivered the address in presenting the gold medal to Professor Simon Newcomb. He was elected Fellow of the Royal Society in 1852. In 1872 he was elected honorary Fellow of Trinity College, and in 1875 he was re-elected an ordinary Fellow, a position which he retained for the remainder of his life. In 1882 he accepted an invitation from the Johns Hopkins University, Baltimore, to give a course of lectures during the winter session. These lectures were delivered in the first five months of 1882.

The honours he received were almost as numerous as could fall to the lot of any scientific man. Degrees were conferred upon him by the Universities of Oxford, Dublin, Edinburgh, Göttingen, Heidelberg, Leyden, and Bologna ; and in 1888 he received, in conjunction with Stokes and Adams, the honorary degree of Sc.D. from his own university. He was an officer of the Legion of Honour ; a foreign associate of the French Institute, and of the Academies of Berlin, Rome, and other cities. He received the Copley and Royal Medals from the Royal Society, the De Morgan Medal from the London Mathematical Society, and the Huyghens Medal from Leyden. His portrait was painted in 1874 by Mr. Lowes Dickinson, and presented by the subscribers to Trinity College, where it now hangs in the hall. A reproduction of this portrait appeared in the sixth volume of his collected works, and a sketch, made at the same time by Mr Lowes Dickinson, was prefixed to the seventh volume. There is also a bust of him in the library of Trinity College.

Towards the end of 1892 his health began gradually to fail, and he had occasional attacks of severe illness, which confined him to his bed for weeks together, each leaving him weaker than before. One of these attacks occurred on 1895 January 8, but he seemed to be getting better, when on January 21 he began to grow rapidly weaker, and died about six o'clock on the evening of Saturday, January 26. He was interred at Cambridge on the following Friday, the funeral service taking place in Trinity College, when the large assemblage of senior members of the University, of the representatives of Governments and societies, and friends from a distance, testified to the respect and estimation in which he was held.

In 1863 he married Susan, daughter of Robert Moline, of Greenwich. His wife and two children survive him. His valuable mathematical library has been presented by Mrs. Cayley to Trinity College and Newnham College. J. W. L. G.

Edward John Collingwood was born on 1815 February 4, at Chirton House, North Shields. His residences were Lilburn Tower and Chirton House, but he sold the latter some years ago. He built an observatory at Lilburn Tower about the year 1852, in which he placed a $6\frac{1}{3}$-inch refractor, equatorially mounted, and a 4-inch transit instrument; but his eyesight failed shortly after the instruments were mounted, and he was unable to do much astronomical work.

He married in 1842 Anna, daughter of the late Arthur Burdett, of Co. Tipperary and King's County, by whom he had issue three sons and two daughters, all of whom survive him. He died at Lilburn Tower on 1895 February 20. Mrs. Collingwood died in 1879.

He was elected a Fellow on 1851 February, but contributed no papers to the Society.

[For these particulars the Council is indebted to his son, Mr. Edward J. Collingwood.]

Richard Dunkin was born at Truro on 1823 June 9. He was the fourth and youngest son of Mr. William Dunkin, who was for nearly thirty years one of the established computers of the old edition of the *Nautical Almanac*, and afterwards a member of the staff of the *Nautical Almanac* office, on its reorganisation in 1831 under the direction of Lieutenant Stratford, R.N., F.R.S. R. Dunkin received his general education at private schools at Truro and Camden Town, London, and finally at a well-known French school at Guines, near Calais, where he remained until the death of his father in 1838 July. In the following month, August 21, through the recommendation of Mr. Davies Gilbert, F.R.S., a Past President of the Royal Society, and Lieutenant Stratford, he and his elder brother were engaged by the Astronomer Royal for special employment in a new department of the Royal Observatory, then recently established

by the late Sir G. B. Airy for the systematic reduction of all the planetary and lunar observations made at Greenwich between the years 1750 and 1830. Richard Dunkin was employed nine years on these laborious calculations, first on the planetary section, and after 1841 on the lunar sections of this important work, the whole of which was carried on in the Octagon Room by a large number of computers. In 1847 August he was appointed an assistant in the *Nautical Almanac* office, on the staff of which he continued a member thirty-six years, retiring in 1883 on a Civil Service pension as a first-class assistant. He had thus an unbroken official service of forty-five years.

When in 1838 R. Dunkin joined the computing staff at the Royal Observatory, the office hours in this special department were excessively long, usually from 8 A.M. to 8 P.M., with only a relaxation of one hour for luncheon at midday. In 1839 the computing-day was reduced to eight hours. The close application required during eleven hours, and even eight hours, without a chance of any variation of work, was almost too great a strain on the nerves of a delicate youth of fifteen. It was, therefore, no wonder that this severe sedentary occupation, coming so soon after the comparative freedom of school-life, unfavourably affected both his bodily and mental health, causing at one time much anxiety to his relatives. There can be no doubt that it was owing principally to this close confinement to the desk in his early years, at a critical period of his life, and also partly on account of his naturally reserved and retiring disposition, that he never felt disposed to undertake any astronomical calculations outside his office, fully believing that it was necessary to reserve all his strength strictly for his work at Verulam Buildings. For many years, however, he took a considerable interest in astronomical questions, and in the general progress of the Society, although he never contributed a paper to its Proceedings. He was also well-informed on several other branches of science, having some acquaintance with experimental chemistry and photography, and also of botany and its scientific classifications, and he had a fair knowledge of general scientific history and literature. He had a great love for French poetry, a taste he acquired during his school-days at Guines, and he was also gifted with a remarkable memory for past events. All these pursuits afforded him a most agreeable pastime during the leisure hours of a considerable portion of his life, but more especially between the years 1848 and 1861.

In the autumn of 1884, about a year after his retirement from the *Nautical Almanac* office, Mr. R. Dunkin went to reside at Truro, in the house in which he was born. Here he passed the remainder of his life in the quiet enjoyment of the study of his favourite subjects, so far as his declining health permitted. During his later years he also took a great personal interest in floriculture, and was very successful in the cultivation of many choice specimens of flowers. He was never married. For a

long time he had been subject to an occasional partial failure of the heart's action. From these attacks he generally soon recovered, but after only a few days' illness from one more severe than usual, aggravated by the intensely cold weather of the winter of 1894–95, he passed away peacefully on the morning of 1895 February 19, in the seventy-second year of his age. He was elected a Fellow of the Society on 1851 June 13. E. D.

Sir Cyril C. Graham, of Kirkstall, was born in 1834. In 1874 he married Louisa Frederica, daughter of the late Rev. Lord Charles Hervey, D.D. Early in 1857 he made a long journey into the higher and less known regions of the Nile, and was rewarded by the discovery of several inscriptions of value. Next he travelled very carefully over the greater part of Palestine and much of Syria. In August 1857 he made explorations of great interest in the desert east of the Haurán and in the land of Bashan, where he discovered very curious inscriptions.

Respecting this last expedition he communicated valuable papers to the Royal Geographical and Asiatic Societies, of both which he was a member.

For the Transactions of the Royal Society of Literature he wrote a further paper on "Additional Inscriptions from the Haurán and the Eastern Desert of Syria," which was edited with a preface and notes by John Hogg, London, 1859.

In 1860–61 he was attached to Lord Dufferin's Mission in Syria (having previously travelled with him in that country in the autumn of 1859) as private secretary. In respect of his services in this capacity Lord Dufferin thus expressed himself: "At the expiration of about nine months our task was successfully terminated; the Constitution then drawn up has ever since rendered the Lebanon the best governed territory in the Turkish possessions. To these results he [Sir Cyril] powerfully contributed. . . . His abilities were certainly extraordinary. He had a peculiar talent for languages, and a most remarkable memory. As for his engaging qualities, they were innumerable."

In 1870–71 he went on behalf of the Hudson's Bay Company on a special mission to Canada and Hudson's Bay Territory to negotiate arrangements between the Company and the Government of the Dominion.

In 1873 Sir Cyril travelled in Russia, from Archangel to Astrakhan, and from the White Sea to the borders of the Kaspian, passing homewards through Daghistan and Georgia. Here, in the Caucasus, his attention was turned to the peculiarities of the Lesghian or Avâr language, on which he communicated a paper of great value to the Royal Asiatic Society in 1881.

In 1875–77 he was Lieutenant-Governor of Grenada in the West Indies, where he succeeded in bringing about an important change in the Constitution, which had previously been found unsatisfactory in its working.

He was a member of the Geological Society. He was an accomplished linguist and philologist, being a master of Arabic and Turkish, well versed in Ægyptology, speaking French, German, and Italian like a native, and knowing much of several other tongues.

Of the Royal Geographical Society he was Foreign Secretary from 1866 to 1871. He succeeded his brother, Sir Lumley Graham, in the Baronetcy on 1890 October 25. He died on 1895 May 9.

[For the above particulars the Council is indebted to Mr. Dudley Hervey, C.M.G., brother-in-law of Sir C. C. Graham.]

John Russell Hind was the son of Mr. John Hind, of Nottingham, lace manufacturer, and was born at Nottingham on 1823 May 12.

He was educated privately and at the Nottingham Grammar School, and at the age of seventeen was sent to London as an assistant to Mr. Carpmael, civil engineer, for which profession he was intended.

But for some years previously he had studied astronomy, of which he soon became an enthusiastic devotee. When he was but sixteen years of age he contributed a number of astronomical notes to the *Nottingham Journal* and other newspapers.

He only remained in Mr. Carpmael's office a short time, his prevailing tastes drawing him still further towards his favourite study, and at the end of the year 1840 he secured, through Sir C. Wheatstone, a post at the Royal Observatory, Greenwich, Mr. Airy, then Astronomer Royal, appointing him to the Magnetical and Meteorological Department. He remained at the Observatory till 1844.

In 1843 he was engaged for a period of three months on the Commission appointed by the Government to determine the longitude of *Valentia*.

On leaving Greenwich he was appointed observer at Mr. Bishop's private observatory in Regent's Park, London, and there he made those discoveries which have rendered his name famous, including 10 new minor planets and 3 comets, besides variable stars and nebulæ. For these discoveries he received one of the twelve testimonials of our Society on that well-known and exceptional occasion in 1848, when these testimonials were to be considered "equivalent to a Gold Medal"; and, further, the Gold Medal actually in 1853. He also received, in 1851, 100*l*. from the Royal Bounty Fund, and in 1852 was granted a pension from the Civil List of 200*l*. per annum "in consideration of his contribution to astronomical science by important discoveries."

In 1851 he went with Mr. Dawes to Sweden to observe the total eclipse of the Sun.

On the death of Lieutenant Stratford, in 1853, Dr. Hind was appointed Superintendent of the *Nautical Almanac* office, which position he held till his retirement under the superannua-

tion scheme in 1891. He continued to exercise a general superintendence over Mr. Bishop's observatory, the actual observers being in succession Mr. Norman Pogson, Dr. Vogel, Mr. Marth, and Mr. Talmage; and on the death of Mr. Bishop in 1861, when his son, George Bishop the younger, removed the instruments to Twickenham, Dr. Hind remained in charge.

Since his retirement in 1891 from the *Nautical Almanac* office Dr. Hind lived quietly at Twickenham, not appearing much in public, nor even visiting the societies to which he belonged; but he still kept up a lively interest in his favourite study, and was a regular subscriber and contributor to the scientific journals at home and abroad. He died at Twickenham, on December 23, 1895, of heart-disease accelerated by a chill, and was buried at the Twickenham Cemetery.

The number of minor planets is now, at the close of this eventful century, which opened with the discovery of the first of them, so large that it is difficult to realise the interest excited by the new discoveries half way through it in which Dr. Hind played so important a part, an interest which would doubtless have been greater still but for the overshadowing of the sensational discovery of *Neptune*. A few of the leading facts may be fitly here recalled; but a glance through our *Monthly Notices* of the period will give a far better idea of these exciting times.

The succession of discoveries was so rapid that a few dates are important. Hencke discovered *Astræa* (5) on 1845 December 8, as the result of a patient search for minor planets, continued during 15 years unrewarded, and after an interval of nearly 40 years since the discovery of the first four. *Neptune* was discovered on 1846 September 23. On 1847 July 1 Hencke discovered *Hebe* (6); and a few weeks afterwards Hind found *Iris* (7), and followed with *Flora* (8) before the end of the year.

Hind's discoveries, like those of Hencke, were the result of a patient search with the definite object of finding minor planets. Mr. George Bishop had determined before building his observatory that it "should do something." A successful business man, he had always had a great wish to possess an observatory, but never the opportunity until he was more than fifty years of age; and being then unable to work personally, he took great pains to get good assistants, and set them to observe with a definite object. "The search for minor planets was commenced in 1846 November, employing the Berlin star maps" (to which attention had doubtless been attracted by the discovery of *Neptune* two months before) "as far as they extended, small stars of 9·10 or 10th magnitude, not marked on the maps, being inserted from time to time as they came under examination."

The first discovery was announced to the Rev. R. Sheepshanks, then vice-president of our Society, in the following letter :—

"3 Allsop's Terrace, New Road, London:
"1847 August 13^d 16^h.

"DEAR SIR,—I have this night discovered another member of the singular group of planets between *Mars* and *Jupiter*. It shines as a star of 8·9 magnitude, the observed positions being—

	G.M.T.	R.A.	δ
	h m s	h m s	° ′ ″
Aug. 13 at	9 35 17	19 57 30·52	−13 27 23·4
	10 45 19	19 57 28·02	−13 27 29·0

showing a retrograde motion in R.A. of 51^s daily. Have I been fortunate enough to detect the lost planet of *Cacciatore?*

"Yours very respectfully,
"J. R. HIND.

"Rev. R. Sheepshanks, M.A."

The discovery of *Flora* on October 18 was also announced to Mr. Sheepshanks by a letter written the same night at 16^h, giving three positions for $11^h\ 40^m\ 4^s$, $15^h\ 4^m\ 10^s$, and $15^h\ 52^m\ 27^s$ respectively.

These two discoveries were rewarded, as remarked above, by a "Testimonial." The exact significance of the term may have been forgotten by some, perhaps by many. The fierce controversy regarding the discovery of *Neptune* paralysed the action of the Council in 1847: they could not decide whether to give the medal to Adams, or to Le Verrier, or to both, and accordingly made no award at all. This course, however, did not remove, but only deferred, the difficulty. The action of the Council was criticised at the time, and as the next annual meeting approached it was felt that the question must still be dealt with. Attempts were made at evasion by advancing the claims of others, of whom Hind and Hencke were put prominently forward. Among the Sheepshanks letters, preserved in our library, there is one of great interest, bearing as it does the signature J. C. Adams, and dated 1847 December 10:—"My counsel would be," writes Professor Adams, "to give a medal each to Hencke and Hind. I think two planets each establish a fair claim. Now is the time to give them. Medals might be given to Sir John Herschel and M. Hansen next year. No one looks upon their works with more respect and admiration than myself, but it would be no slur upon them to give the medals this year for such a widely different department of science, not at all coming into competition with either of their subjects." Nothing could be more characteristic of the great man we lost a few years ago than this anxiety to have his own claims put aside, nor more effective in indicating the estimation in which the discoveries of Hencke and Hind were held in this eventful period.

The solution of the difficulty arrived at was the award of Testimonials "in place of and in the same rank with the usual Medal" to twelve persons, including Adams and Le Verrier,

Hencke and Hind, Sir John Herschel and M. Hansen, and, it may be remarked, Mr. George Bishop, who had founded the observatory where the planets were discovered. Of these twelve, Dr. Hind was at his death the sole survivor; nor is there now alive any member of the Council which dealt with these burning questions. The expedient of a Testimonial has never since been resorted to.

It fell to Sir John Herschel, himself one of the recipients, to deliver the address on the merit of those who received Testimonials. In speaking of Dr. Hind he remarked: "No name comes oftener before the astronomical world, as an assiduous observer and able computist in the department of astronomy which the nature of the instrumental means committed to his charge gives him an immediate connection with, as a diligent observer of double-stars and computer of their orbits, for instance, or as the first detector of several comets, one of them a very remarkable one, which, from his calculation of its orbit, he was enabled to follow up to its actual perihelion, and to behold it at noon-day presenting a clear and well-defined disc within 2° of the Sun."

This sentence reminds us that even before the discovery of *Iris* and *Flora*, Dr. Hind was already a discoverer of comets and an astronomer of distinction. He was also Foreign Secretary of our Society.

In 1853, when the number of his planetary discoveries had been increased to eight, Hind received the Gold Medal itself from the hands of Adams. After this he found two more planets; but the list closed when he settled down at the *Nautical Almanac* Office in 1854.

One or two circumstances connected with the naming of the early discoveries may be noted here. The name *Iris* was proposed by De Morgan, who also suggested a symbol. Writing to Sheepshanks (1847 August 22) Hind says, "I find the name is approved at Cambridge and Greenwich, though *Thetis* was preferred. However this will do for the next, if no better is to be found." The name *Thetis* was not, however, used till the discovery of (17) by Luther in 1852.

On the discovery of (12) in 1850, the Americans strongly objected to the proposed name *Victoria*, which happened to be also that of our Sovereign. Indeed, they went so far as to substitute *Clio*, and the Astronomer Royal wrote, "When I looked for *Victoria* in the index to *Gould's Journal* and expected at least to find '*Victoria*—see *Clio*,' and found it not, I was very indignant." At the same time he advised Dr. Hind not to use the name *Clio* for a subsequent discovery in 1852, which "would cause much confusion and would be interpreted as exhibiting a too angry temper." The name *Clio* had been apparently suggested by Adams, or at least approved by him. "*Clio* is the name which I should have preferred," he writes, "but since Mr.

Airy so strongly objects, and others may perhaps take the same view, it is perhaps better not to risk the breaking of unanimity ;" and he goes on to suggest *Calliope*. The choosing of this name was attended with more than ordinary interest, since the planet had been discovered on the morning of the Duke of Wellington's funeral ; hence the name of *Calliope*, "whose office in ancient mythology required her to perpetuate the illustrious deeds of heroes." The rejected name *Clio* was not used till the discovery of (84) in 1865 (curiously enough by Luther, who had previously appropriated the rejected name *Thetis*).

Besides minor planets and comets, Hind discovered two objects of conspicuous interest—viz., the "new star" in *Ophiuchus* ; and the variable nebula in *Taurus*, the variability of which has been recently confirmed by Barnard and Burnham. His following of a comet into full sunshine has already been mentioned in the words of Sir John Herschel. His prediction of the "return of the Great Comet of 1264 and 1556" was not so successful, minuter examination showing that perturbations vitiated the results. The prediction appeared in the *Monthly Notices*, and also in a separate work. Of other works on Astronomy by him the chief are *The Solar System*, *Recent Comets and the Elements of their Orbits*, *An Astronomical Vocabulary*, and a *Descriptive Treatise on Comets*. His list of scientific papers is a very long one, and he contributed to many periodicals.

Dr. Hind was elected a Fellow of this Society on 1844 December 13. At the same meeting was elected as an Associate Signor Cacciatore, whose "lost planet" Hind had been inclined on the night of discovery to think that *Iris* might be. At the preceding meeting Sir John Herschel had read his memoir on Francis Baily, who had died while President for the fourth time ; but although the date of Dr. Hind's election thus links us with the foundation of our Society, three of our present Fellows were elected before him. In 1846 he was placed on the Council, and in 1847 he succeeded Sir John Herschel as foreign secretary, which position he retained till 1857. In 1880 he was elected President, and he presented the medal to Dr. Axel Möller and to Dr. Gill. It is proper to mention here the work Dr. Hind undertook for the Society in superintending the comparison of Hansen's and Burckhardt's tables of the Moon for the years 1847–1865, published as an appendix to vol. l. of our *Monthly Notices*.

In 1847 he was made a corresponding member of the Société Philomathique of Paris. In 1850 he was one of a Commission, for the Exhibition of 1851, respecting machinery as applied to direct use. In 1851 he was elected a corresponding member of the Academy of Sciences of Paris, in the place of Schumacher. There were eighteen candidates for the election, Dr. Hind being chosen by forty-five out of forty-six votes. The same year he was made a Fellow of the Royal Society, and subsequently he was elected into the Royal Society of Edinburgh, the Imperial

Academy of Sciences of St. Petersburg, and the Swedish Royal Society (Lund). He was also made Hon. LL.D. of the University of Glasgow. He was the recipient of many medals, the chief of which were the gold medal of the Royal Society, the gold medal of the Royal Astronomical Society, a gold medal from the King of Denmark, six times the Lalande medal (with money prizes amounting to over 60*l.*), and a medal from the French Institute, struck to commemorate the discovery of one hundred minor planets, in 1869. The obverse of this medal consisted of the profiles of the Englishman, the Frenchman, and the German, who had discovered most of these planets, the Englishman represented being Dr. Hind.

It is curious that during the years of his greatest activity (1844–1856) Dr. Hind suffered from extreme bad health. Physically he was apparently a strong man, but he was excessively nervous and frequently had to give up work for a time on account of "excessive nervous exhaustion." He was of a most retiring disposition, and worked more for science' sake than for the approbation of his fellow-men or for his own pecuniary advancement. In his diary, under date 1849 January 15, he wrote, "I mentioned to Mr. Airy to-day that I thought very soon I should have to relinquish observations at night entirely," but happily a few months' rest enabled him to resume work and complete the task he had set himself to do.

He married in 1846 and had six children. For the personal details of the above notice, and for much valuable assistance, the Council is indebted to his son, Mr. T. Almond Hind.

Frederick Robert Hughes was born in London on 1807 November 29. His father was a clergyman, and volunteered as a missionary to Sierra Leone; but both he and his wife died soon after their arrival, and their son returned to London, where he was brought up under the care of an uncle. He received a liberal education; and when a young man held an appointment in a chemical manufactory till 1830, when he removed to Borrowstowness, in Scotland, and very soon afterwards went into partnership for the manufacture of prussiate of potash, to which was subsequently added that of iodine from kelp. After a prosperous business career he retired in 1877. He enjoyed good health until within about a year of his death, at Borrowstowness, on 1895 March 11. His wife died in 1840, but a daughter (the wife of Colonel Harwood, of Sanday, Orkney, to whom the Council is indebted for this notice) survives him.

He was deeply interested in science, especially astronomy, optics, and mathematics, and had numerous appliances specially constructed for him. He possessed a fine equatorial by Cooke, and many other instruments.

He was elected a Fellow on 1866 January 12, but contributed no papers to the Society.

Captain A. Lister Kaye was born at Denby Grange, near Wakefield, on 1834 May 12. He entered the Royal Artillery and served in the Crimea, for which he received the Crimean Medal and Turkish Clasp of the Order of the Medjidie. He was also twice with his regiment in India. He left the Army in 1865 and lived at the Manor House, Stretton-on-Dunsmore, Rugby, till his death on 1893 December 5. He married in 1867, and leaves a widow, two sons, and three daughters.

He possessed a 4-inch refractor by Cooke, and a transit, and observed sun-spots and double stars.

He was elected a Fellow in 1882 November, but contributed no papers to the Society.

[For the above particulars the Council is indebted to Mrs. Lister Kaye.]

Arthur James Melhuish was born in London in 1829. In 1853 he married Caroline Powell, of Tiverton, Devonshire, by whom he had seven children—three sons and four daughters. He lived for some years at Blackheath, but came to London in 1863, and resided for many years at 12 York Place, Portman Square (the house formerly occupied by William Pitt). He died at Brondesbury on 1895 November 1. In 1873 he started, in conjunction with Mr. Alfred Wilcox, the *Church of England Pulpit and Ecclesiastical Review*, which is still carried on, though now in other hands. He is the author of a work on "Mental Analysis," and of many papers published in various magazines—"The Geology of the Bible," "Truth about Ghosts," "Good Fools," &c.

He was elected a Fellow in 1863 January, but contributed no papers to this Society. He was an Honorary Fellow of the Meteorological Society.

[For the above particulars the Council is indebted to Mr. A. Newton Melhuish, son of our deceased Fellow.]

Oluf Andreas Löwold Pihl was born 1822 December 5 in Stavanger, Norway, where his father was a merchant. Mechanical ingenuity has been characteristic of several members of this family. Oluf Pihl's grandfather, a country clergyman at the close of the last and the beginning of this century, was not only an astronomical observer, but had in his residence in Hedemarken, near the lake of Mjösen, a real workshop for clocks, speculum-telescopes, and other astronomical and physical instruments. The University Observatory in Christiania is in possession of some instruments of his making, *e.g.* an artificial horizon of glass, with level, and a clock with gridiron pendulum, which is still in use in the meteorological room of the Observatory, and has several times been used as an electrical transmitter for coincidences of clock signals in longitude determinations. A box chronometer, used by Oluf Pihl for his astronomical observations, was also of his grandfather's making.

Oluf Pihl's mechanical abilities having made their appearance in early boyhood in the usual manner by his taking watches to pieces and putting them together again (his first positive enterprise in this way was to put a new spring in the watch of a fellow-schoolboy who had dropped it in the street, but dared not tell the misfortune to his father), he was sent to England to be an engineer. Here he made the acquaintance of a Norwegian engineer, Mr. Sörensen (later on for many years director of the mechanical works of the Royal Norwegian Navy), and of a Swedish Count Rosen, an amateur engineer, who had formerly taken part in the Greek War of Independence, and was then living in London. By their advice he went to Sweden, after a year's stay in England, to obtain the necessary theoretical training at a technical school in Gothenburg, where he remained for three years. Returning thence to England, he worked first under the celebrated John Ericson, at that time residing in England ; next in one of Robert Stephenson's engineering offices ; and lastly as a constructor under the engineer for the Huddersfield-Manchester Railway. In 1849 he left for Christiania and took, in the following year, the direction of the gasworks, in which position he remained till a month before his death in 1895. He has also taken part in the construction of waterworks and other engineering works in Norway, partly in collaboration with his younger brother, Carl Pihl, now one of the directors of the Norwegian railways.

Oluf Pihl's deep interest in the sciences was greatly stimulated during his stay in England. Amongst others he made here the acquaintance of Dr. Lee at Hartwell, in 1861 and 1862 President of the R.A.S. Some years after his returning to Christiania Pihl bought a small property, formerly the country house of the Norwegian poet Tullin (now long ago included in the town), and added to it a tower, in which he set up an equatorially mounted telescope of $3\frac{1}{4}$ inches aperture. With this he commenced a series of observations of the cluster Messier 34 (in *Perseus*), the results of which he published in 1869 under the title of *Micrometric Examination of Stellar Cluster in Perseus*, containing the results of the separate observations and a catalogue for 1865·0 of 85 stars between $2^h\ 31^m$ and $2^h\ 36^m$ in R.A. and 41° 56′ to 42° 26′ in declination.

Immediately after the completion of this series he took up a new and more extensive work, the observation of the following group of the great double cluster in *Perseus*. The resulting catalogue for 1870·0, containing 236 stars in R.A. $2^h\ 11^m$ to $2^h\ 16^m$ and Decl. 56° 11′ to 56° 49′, was not published till 1891 under the title *The Stellar Cluster* χ *Persei micrometrically surveyed.* In the preface the author says : "That so long a period as about twenty years has elapsed between the commencement and completion of the present work is owing, not so much to the limited time which I, as a business man, have had at my disposal for scientific occupation, as to the fact that during a long series of years,

and up to a comparatively short time ago, I was in very bad health, and therefore during many years almost, if not quite, cut off from all work in my observatory during the cold season, when that work which required most time had to be carried out."

A comparison with the results of previous observations of parts of the same cluster induced Pihl to make an investigation of a peculiar difference, evidently of physiological origin, between the results from occulting micrometers, which he had used in all his observations, and other micrometers. The investigation was given in the publication *On Occulting Micrometers and their Value as applied to exact Astronomical Measurements* (Christiania, 1893).

Among other mechanical contrivances with which Pihl occupied himself in his leisure hours was the construction of electrical clocks. His own house, as well as those of his three sons, was furnished with such, made by his own hands. The construction of the apparatus for giving the appulse to the pendulum had in early years led him to an investigation of magnetic attraction at short distances. Here he met with the problem of calculating, from the known fundamental law, the attraction between two parallel circles (surfaces or peripheries). As this leads to elliptical integrals, which, he could not master, he resolutely split up the areas or peripheries into small parts and made a direct calculation, partly by construction and interpolation. The results of these calculations, for several dimensions and distances, he has given in *Christiania Videnskabs-Selskabs Forhandlinger*, 1876 and 1881. The whole investigation, which included a very extensive series of experiments of different kinds, partly made with apparatus of his own construction, was published in 1878 in a book of 135 pages, *On Magnets*, forming an appendix to the proceedings of the said society.

Pihl was elected a fellow of the R.A.S. 1860 November 9, and has contributed some papers to vols. xxviii., xxix., and xxxiii. of the *Monthly Notices*, dealing partly with his observations of stellar clusters, partly with the meteoric showers of 1866 November 13–14 and 1872 November 27.

In 1850 he married a Swedish lady, Miss Tranchell, after whose death, in 1894, his own health rapidly declined. After suffering some time from Bright's disease he died 1895 July 1. His deep interest and extensive knowledge in science, his love of music, and his amiable hospitality will be remembered, not only among his countrymen, but certainly also among many foreign friends.

[The Council is indebted to Prof. H. Geelmuyden, of the Christiania Observatory, for the above notice.]

Alfred White was born in Holborn on 1811 March 3. He was the elder son of Paul Sleath White and grandson of William White (the first Grand Secretary of the English Freemasons and Secretary of the Honourable Artillery Company, Finsbury),

descended from the Whites of Cork, Ireland, and Dr. Paul Limrick, D.D., Rector of Scull, co. Cork, Ireland.

He was head of the firm of Alfred White & Sons, manufacturing chemists, of Castle Street, Saffron Hill, London, and West Drayton, Middlesex, which was established in 1775.

His residences were Horton Field, West Drayton, Middlesex, and Ashingdon Hall, Rochford, Essex.

Although he took great interest in astronomical research, his chief studies were archæology and chemistry.

He was Fellow of the Linnean Society, Fellow of the Society of Antiquaries, Fellow of the Chemical Society, &c.

He married (1845 November 6) Marianne, eldest daughter of the late Rev. Thomas Pugh, at Redbourne, near St. Albans, Herts (she died 1879 October 9). Issue, four sons and three daughters, all of whom are living except his eldest daughter, who died 1865 March 12.

He died at Horton Field, West Drayton, on 1895 March 8, being eighty-four years of age, and was buried in the family vault in Hillingdon Churchyard, Middlesex, with his wife and eldest daughter.

For the above particulars the Council is indebted to Mr. P. T. White, son of Mr. Alfred White. This death closes the list of Fellows of the Spitalfields Mathematical Society, who were elected Fellows of this Society in a body on 1845 June 13; and it is perhaps a fitting opportunity to reprint the account of the circumstances attending this election, as given in *Monthly Notices*, vol. vi. p. 256 :—

"The President then announced that in pursuance of a resolution of the Council, which had been duly intimated to the Fellows, as required by the Bye-laws, the business of the Ordinary Meeting was now concluded, and that a Special General Meeting would immediately be held, to take into consideration a subject, of which due notice had been given to the Fellows by the following circular, which he requested the Secretary to read :—

"'Somerset House, June 5, 1845.

"'Sir,—I have the honour of notifying to you that in pursuance of a Resolution of the Council, passed on Friday, the 23rd of May last, a Special General Meeting of this Society will be held at the Society's apartments on Friday, the 13th day of June instant, immediately after the business of the Ordinary Meeting to be held on that day is concluded, for the purpose of taking into consideration and deciding upon a recommendation of the Council to suspend upon that occasion the Bye-laws relative to the Election of Fellows, and to elect as Fellows of this Society the remaining Members of the Mathematical Society (now reduced to nineteen in number, of whom three are already Fellows), without payment of the usual Admission Fees and

Annual Contributions (or compositions in lieu thereof), the Mathematical Society having announced its resolution to transfer its valuable Library, with its Records and Memorials, to the Royal Astronomical Society.

" 'I have the honour to be, Sir, your most obedient servant,

" 'ROBERT MAIN, Secretary.'

"It was then moved by Professor De Morgan, seconded by Mr. Galloway, and resolved unanimously :—

" 'That the recommendation of the Council in the circular now read be approved and adopted by this Meeting ; and that on the Library, Records, and Memorials of the Mathematical Society being delivered over to this Society, the following sixteen gentlemen, Members of the Mathematical Society, be admitted Fellows of the Royal Astronomical Society without payment of the admission fees or annual contributions required by the Bye-laws—viz. :

William Wilson, Esq.	Thomas K. White, Esq.
Robert Graham, Esq.	Philip James Chabot, Esq.
Robert Porrett, Esq.	Charles O. Dayman, Esq.
James Scott Bowerbank, Esq.	Thomas Cooper, Esq.
Julius Page, Esq.	John Walton, Esq.
John Williams, Esq.	Jacob Hoyer, Esq.
Henry De Berckem, Esq.	Robert Arthur Graham, Esq.
Alfred White, Esq.	Thomas Taylor, Esq.

and that the remaining three members of the Mathematical Society—viz. :

Benjamin Gompertz, Esq.	John Lee, Esq.
John James Downes, Esq.	

or such of them as are liable to the payment of Annual Contributions, be exempted in future from such liability.' "

At the meeting of 1845 November 14 "Mr. Stratford stated that the books received consisted of

76	volumes	folio
622	„	4to
1,442	„	8vo
311	„	12mo

131 books not bound or catalogued, and that six volumes were yet to be delivered ; that the Council had this day determined to complete the deficient sets of the most valuable works, to rearrange the library, and to prepare a new catalogue, uniting the books of the two societies as early as possible."

PROFESSOR DR. FRIEDRICH WILHELM GUSTAV SPÖRER was the son of a merchant of Berlin, in which city he was born on

1822 October 23. He was educated at the Friedrich Wilhelm Gymnasium and at the University of Berlin. Here he studied under Steiner, Ohm, Minding, Poggendorf, Mitscherlich, and other professors, but those who exercised the greatest influence upon him were Encke and Dove. He took his degree in Mathematics and Astronomy in 1843, and obtained his doctorate for a thesis entitled "De Cometa qui anno 1723 apparuit." In 1844 he served as a computer under Encke at the Berlin Observatory, and he computed the perturbations of Encke's comet for the period 1838 to 1845; later he derived the elements of the comet from the apparitions of 1819–1838, and computed its ephemeris for a part of the year 1845. This first contribution to astronomy appeared in the *Astronomische Nachrichten*, and was incorporated in a paper on that comet by Encke himself. From 1846 until 1874 he adopted the profession of teaching. He first went to the Gymnasium at Bromberg, as instructor in mathematics and natural science; in 1847 to Prenzlau; and in 1849 to the Grammar School at Anclam, where he occupied a post for twenty-five years and was eventually elected pro-rector. But though engaged in other occupations he did not lose his strong early love for astronomy, and by the year 1860 it led him to devote his leisure hours to that systematic study of Sun-spots which has made his reputation as an astronomer. Though at first provided with but a small and indifferent telescope, furnished only with a ring micrometer, he quickly brought out his first results; the earliest of the long series of solar observations which he communicated to the *Astronomische Nachrichten* appearing in No. 1315, with date 1861 June 13, and bearing the title "Beobachtungen von Sonnenflecken und daraus abgeleitete Elemente der Rotation der Sonne." In this paper he gives the rotation period of the Sun as deduced from the observation of a number of spots, which appeared to him to be of a stable character. Having found the inclination of the Sun's equator to the ecliptic to be approximately 7° 30′, and the longitude of the ascending note to be 78°, he computed the heliographic coordinates for a considerable number of single spots, and from each series the angle of rotation of the Sun (ξ) and its time of rotation (T) were deduced. The means of these values were $\xi = 14°{\cdot}2965$ and $T = 25^{d}\ 4^{h}\ 21^{m}$. This paper and the similar communications which followed it brought him under the notice of many men of distinction and influence, amongst others of Professor Schellbach, the tutor to the Crown Prince Frederick William (afterwards the Emperor Frederick). In recognition of the good work that he had done the Crown Prince gave him in 1868 a good 5-inch glass equatorially mounted and driven by clockwork. In the same year he went to the East Indies with Professor Tietjen and Dr. Engelmann to observe the total solar eclipse at Mulwar, in the Bombay Presidency, in longitude $5^{h}\ 3^{m}\ 21^{s}$ east, and north latitude 16° 34′·7, but clouds prevented the observation of totality. This was the only interruption of a considerable length of time

that his Anclam observations experienced. Six years later he accepted an official position in the Astrophysical Observatory at Potsdam, and was promoted to the rank of "Chief Observer" in 1882. His researches during these latter years (1871–1893) are contained in the Publications of the Astrophysical Observatory, and his concluding observations appeared in the first half of the tenth volume, issued very shortly before he died. Professor Vogel's farewell to his chief observer and colleague in the Introduction came, therefore, pathetically soon before his death. The director says that with the "first part of this publication Professor Spörer closes the long list of his works on Sun-spots. The results of his labours given in the Publications of the Astrophysical Observatory embrace a period of over twenty-two years, from 1871 October 1 to 1893 December 31, and constitute an eloquent testimonial to the untiring industry and the great sense of duty of the renowned observer, who leaves the ranks of my colleagues on 1894 October 1, and enters into a well-earned rest." That rest he did not long enjoy, for he passed away at Giessen, on 1895 July 7, while on a visit to his children, without having sustained any weakening of his mental or physical powers or any previous indication of the disease which caused his death—paralysis of the heart. Professor Spörer left three sons and four daughters. One daughter was married to Professor Müller, Observer at the Observatory of Potsdam, and author of several astronomical works.

His colleague, Dr. O. Lohse, sums up his character in the following terms :—

"Spörer was a genuine Berliner of equable and cheerful temper ; he bore all the vicissitudes of life with undisturbed equanimity, and always at once reverted to his daily routine, *i.e.* to his study of the Sun, now so beloved by him. His constancy in this occupation as well as his conscientious discharge of his official duties was worthy of all admiration."

Amongst the recognitions which his long-continued labours received from foreign nations may be mentioned his election as Corresponding Associate of the Società degli Spettroscopisti Italiani on 1889 February 10, and the award to him on 1885 December 14 of the Valz Prize of the Institute of France.

The chief results of Spörer's labours in the field which he made so thoroughly his own were the redetermination of the mean rotation period of the Sun, resulting in a slightly different value from that found by Carrington—25·445 days as against 25·38 for latitude 15°—the confirmation of Carrington's observation of the decrease of the angular velocity of Sun-spots, with their distance from the equator ; the determination of the amount of this drift, and its representation by a simple empirical formula—$\xi = 8°{\cdot}548 + 5°{\cdot}798 \cos$ (lat.)—the determination of the length of the Sun-spot cycle from observations extending over 38 years ; and the demonstration that the progress of the cycle not only involves

a change in the numbers and areas of the spots, but also in the zones which they affect; so that at the beginning of a new cycle the spots are found chiefly in high latitudes, but as the cycle progresses ever in lower latitudes, until at length the equator is reached. A feature of this "law of zones," which he pointed out, is the associated fact that the actual Sun-spot cycles overlap, the new current having its beginning before the expiring one has run out to its close. Besides his own observation of Sun-spots, Professor Spörer was indefatigable in searching out early records, and in two papers entitled, "Ueber die Periodicität der Sonnenflecken seit dem Jahre 1618," and "Sur les Différences que présentent l'Hémisphère nord, et l'Hémisphère sud du Soleil," communicated respectively to the Royal Leopold-Caroline Academy and to the *Bulletin Astronomique*, he traced back his "law of zones" to the year 1619, and showed that although there is on the whole an even balance between the number of spots in the two hemispheres, yet in three periods of the Sun's history the southern spots have predominated. A third and most interesting fact brought out in these papers was that of the apparent suspension of both the law of the spot cycle and the "law of zones" for about 70 years at the end of the seventeenth century. Dr. Spörer's regular observations of Sun-spots from his rotation No. 1 in 1861 January to rotation 445 in 1894 January are published in six volumes. The first two, or the Anclam observations, were issued as the thirteenth volume and its appendix of the publications of the *Astronomische Gesellschaft* in 1874 and 1876. The remaining four are contained in the *Publications of the Astrophysical Observatory of Potsdam* as vol. i., No. 1; vol. ii., No. 5; vol. iv., No. 17; and vol. x., No. 32. These volumes are illustrated by charts showing, rotation by rotation, the arrangement of the spots in longitude and latitude, in a somewhat similar form to that adopted by Carrington.

Professor Spörer was elected an Associate of the Royal Astronomical Society on 1886 November 12.

Friedrich Tietjen was born on 1832 October 15 at Garnhold, a village of Westerstede parish, in the Duchy of Oldenburg. His father owned a small farm, and Friedrich, on the early death of his elder brother, remained the eldest of six children and heir to the property. He was educated at first in a volksschule, and here showed great inclination and aptitude for figures; but this fact had little interest for his father, who was chiefly concerned that his son should be a good farmer, and to that end required him, even before he left school at the age of fifteen, to work in farm and field like other boys. Mathematics had, however, a special attraction for him, and he taught himself from such books as he could borrow, though his studies could only be pursued at night after a hard day's work, and if not perhaps unknown to, at any rate much against the will of, his father. It was contrary to all traditions of the family that the eldest son should resign

his birthright, but the father determined that the farm should at least be handed over to a sturdy farmer, and not to a student. This was a trying time for the young man, who could with difficulty conceal his own inclinations. A chance of escape suggested itself in his military service, for he hoped to get to Oldenburg, and there find opportunity for further education. But he was rejected from physical weakness, and his grief and despair were so great that his father, who had hitherto refused to listen to the advice of his old friends, at last realised that his son would never make a farmer. He accordingly yielded to his son's wishes, on the condition that he resigned his birthright. Tietjen forthwith went to the high school at Oldenburg, and found in Professor Harms an exceptionally able instructor in those mathematical studies which he loved. Thence he proceeded to the Collegium Carolinum in Brunswick, where his diligence and ability were so manifest that in 1859 he entered the University, though at the advanced age of twenty-seven.

Next he went to Göttingen, and a year later to Berlin; and here it was that his love for astronomy was awakened. He began in 1861 to busy himself with observations and reductions of small planets and comets, and in 1862 was appointed by Professor Encke second assistant in the Observatory, with charge of the great refractor and magnetic observations. In 1865 Professor Foerster succeeded to the directorship of the Observatory, and Tietjen became first assistant, in which position he remained until 1874, when he was appointed Editor of the *Berlin Jahrbuch* and Director of the new Rechen-Institut, founded in connection with the Observatory. With Professor Foerster he undertook the management of a school of instruction in scientific computations; and in 1878 succeeded Professor Bremiker as Editor of the *Nautisches Jahrbuch*.

Tietjen worked very hard during his thirteen years as assistant at the Observatory, especially at observations of small planets, to which the *Berlin Jahrbuch* pays special attention. The situation of the Observatory in the midst of the city made such work very difficult and laborious. In 1866 he had the good fortune to find one planet—*Semele*—himself, in watching the recently discovered *Io*. From the year 1869 he did a large amount of work in observing comparison stars with the large transit circle. The accounts of his work of this kind, as well as of his magnetic observations at Berlin, in the *Astronomische Nachrichten* and the publications of the Observatory, testify to their great value.

Some other matters claimed his attention. In the course of the Mid-European Survey it was resolved to fix the astronomical position of some point in Oldenburg, and the selection fell on Dangast, the position of which was determined by Tietjen in the summers of 1866 and 1867, with the help of Professor Albrecht for the longitude work. In 1868 Tietjen spent some time in Gotha, working at perturbations under Hansen's superintendence; and

undertook some calculations for a new theory of *Jupiter*, which were, however, interrupted by the expedition to observe the Total Solar Eclipse of 1868 August 18. Two expeditions were sent—to Arabia and to India—by the Prussian Government.

He also undertook spectroscopic observations on several occasions. In 1868–9 he made an unsuccessful series of attempts to see protuberances without a spectroscope by absorption of the general light of the Sun. In 1872, at nearly the same time as Respighi, he found that the strongest line in the spectrum of the zodiacal light can be seen in all parts of the sky. And, finally, in 1873 he measured the hydrocarbon bands in the spectrum of Encke's Comet with a spectroscope designed for the purpose.

From 1874, when Tietjen undertook the editorship of the *Berliner Jahrbuch* (first jointly with Foerster, later alone) and the directorship of the Rechen-Institut, he practically ceased observing, and turned his attention to theory and computation. He was a ready and most accurate computer, and undertook many investigations of his own, in addition to the heavy regular work. The *Jahrbuch* under his editorship kept pace with the advances of knowledge; and several appendices contain personal contributions of great value, chiefly relating to the determinations of planetary orbits and improvements in the methods of reduction.

Tietjen was an indefatigable worker. He had a wonderful faculty for solving instrumental and mechanical problems, of great use in the Observatory work. The number of his publications would have been greater could he have found opportunity to carry out all his ideas. Against his undoubted faculty for arranging them, and condensing them into scientific results, must be set a certain natural disregard of form, perhaps due to his exceptional early life and late development, which he could never shake off, and which appeared also in his private life. A somewhat rough exterior hid, however, a heart of gold. By his colleagues, friends, pupils, and by his countrymen of all ranks, was he beloved and respected, and the simplicity and uprightness of his character will long live in their memory.

He was of sound constitution, and though he did not spare himself, never ill. About the end of the eighties he began to suffer from shortness of breath, which gradually developed and, complicated by heart-disease, made his last years sad and painful. Visits to baths and a winter in Italy (1894–5) only brought temporary relief, and on 1895 June 21 he died.

Tietjen was elected an Associate of our Society on 1881 June 10, together with Gyldén, E. C. Pickering, Tempel, and Tisserand. His name occurs four times in the index to volumes i. to xxix. of the *Monthly Notices*, and twice in the index just published, as contributing elements of minor planets, but these elements were always copied from the *Astronomische Nachrichten*.

[For the above particulars of his life and work the Council is indebted to his close personal friend Dr. H. Romberg, of Berlin.]

Proceedings of Observatories.

The following reports of the proceedings of observatories during the past year have been received from the Directors of the several observatories, who are alone responsible for the same :—

Royal Observatory, Greenwich.

With the transit-circle 12467 observations of transits and 12445 of meridian zenith distances were made in 1895, giving an average, excluding Sundays, of about 40 per night. About 3000 observations were made in the two months of August and September. The total number of stars observed during the year is 2633.

The Moon was observed 137 times with the transit-circle; the mean error in R.A. of Hansen's Lunar Tables with Newcomb's Corrections deduced from these observations is $-0^{s}\cdot065$. The errors for the years 1883–95 are as follows :—

	s		s		s
1883	+0·032	1888	+0·079	1893	+0·036
1884	+0·021	1889	+0·010	1894	−0·019
1885	+0·028	1890	+0·020	1895	−0·065
1886	+0·029	1891	+0·079		
1887	+0·068	1892	+0·069		

The number of observations of pairs of reflexion and direct observations of stars in zenith distance was 642. The apparent correction to the Nadir observations deduced from these varies from $+0''\cdot03$ to $-0''\cdot50$ in the several months of the year. The mean for the year is $-0''\cdot26$, agreeing with the results of the three previous years. For the years 1890 to 1894 the corrections are $+0''\cdot08$, $+0''\cdot07$, $-0''\cdot25$, $-0''\cdot34$, $-0''\cdot27$.

The series of observations begun in 1894 December, in which pairs of stars of nearly the same N.P.D., and at an interval of 5 or 10 minutes in R.A., are observed in zenith distance, the one directly and the other by reflexion, alternately on alternate nights, was continued during the year. Altogether 320 observations have been made up to the end of 1895, giving 160 determinations of the R—D discordance.

The personal equation machine has been used to determine personality in observations of the first and second limbs of the Sun or Moon. Altogether 24 determinations of the personality of six observers have been made during the year.

The Moon has been observed with the altazimuth in the first and last quarters as in previous years, 66 observations being made in the year. The building of the new altazimuth pavilion was completed, and the dome erected in the autumn. The heavier portions of the new altazimuth were placed on the pier on May 6, and the instrument is now being mounted. A working catalogue of fundamental stars for the azimuths in which the instrument will be used has been prepared, as well as various tables required in the reductions.

Two comets were observed during the year with the Sheepshanks equatorial : Encke's comet on eight nights, and Comet (*d*) 1895 on one night ; Comet (*c*) 1895 (Perrine) was observed with the altazimuth on two nights.

Forty-eight occultations of stars by the Moon were observed during the year, 21 of these, of which altogether 139 observations were made by 11 observers, occurring during the total lunar eclipse of 1895 March 10. Thirty-two phenomena of *Jupiter's* satellites were observed with the altazimuth or one of the equatorials.

With the 28-inch refractor 277 sets of micrometric observations of 153 double stars have been made, all the measures of a star on one night (usually 4 of distance and 3 of position-angle) being counted as one set. In 92 stars the distance between the components was under $1''\cdot5$, and in 30 of these under $0''\cdot5$. A good series of measures of κ *Pegasi*, a pair which is closing rapidly, has been obtained, the last measures being made on November 18, when the distance apart was less than $0''\cdot1$. Measures of the diameters of *Jupiter* and his satellites begun in 1894 were continued on 19 nights. Altogether 263 measures were made of *Jupiter's* equatorial diameter, 216 of the polar diameter, and about 50 measures of the equatorial and polar diameters of each of the satellites. In addition to these 100 measures of *Jupiter's* equatorial diameter were made with the double-image micrometer. About 800 measures of the diameters of *Saturn* and his rings and of the diameter of *Titan* were made on 14 nights with the filar micrometer. The measures of *Jupiter* and *Saturn* have been published in the *Monthly Notices*, and the measures of double stars will be communicated to the Society shortly.

With the half-prism spectroscope 284 measures have been made of the displacement of the F line in the spectra of 29 stars, and 15 measures of the *b* line in the spectra of 4 stars ; 38 measures of the displacement of these lines in the spectrum of the Moon have also been made as a check on the adjustments. A few experiments have also been made in photographing stellar spectra.

A considerable improvement in the conditions of observing with the 28-inch equatorial has been effected by the use of canvas sails to act as wind screens on the two sides of the shutter opening of the 36-feet dome. These sails, which were completed at the end of February, are each 22 feet high by 8 feet wide, and can be hauled up and down easily by peculiar tackle specially suited to the conditions of the case.

The photographic telescope of 26 inches diameter presented by Sir Henry Thompson is being constructed by Sir H. Grubb, and will, it is hoped, be ready very shortly for inspection at his works. The crown disc for the 26-inch object-glass was supplied last March, the flint having been delivered in the previous August.

With the Astrographic Equatorial (which was not in use till February 25, during the repair of the shutter, which was blown off the dome during the gale on 1894 December 22) 547 plates with 1,382 exposures were taken in the year 1895 on 120 nights; and of these 138 have been rejected—viz. 53, as not coming up to the standard in showing faint stars; 41, from the *réseau* not being printed sufficiently clearly; and 44 on account of partial fogging, wrong setting, faulty development, or mechanical injury. Of the 409 successful plates, 82 are for the Chart, 263 for the Catalogue, 45 are Standard Areas, 10 for the adjustments of the instrument, 5 are photographs of other regions, and 4 were taken with the enlarger (enlargement six times). When practicable a trail has been taken each night on a catalogue plate, and 72 plates with trails have been secured.

Each plate has undergone a preliminary examination to see whether it was generally satisfactory, and whether the limits of magnitude were approximately reached as inferred from the 20^s exposure, which should give 9th magnitude stars of Argelander's scale. When the measurement of the Catalogue plates was begun, it was found that many photographs which had been previously passed were not suitable for measurement with the glass-scale micrometer. A revision of the plates previously passed has been made, and such as were not considered suitable for measurement have been rejected.

The following table shows the progress made in the photographic mapping of the heavens up to the end of 1895:—

Zones Decl.	No. of Fields Required.	No. of Fields Photographed For Catalogue.	For Chart.
65°–69°	376	354	224
70–75	360	255	184
76–80	216	76	71
81–90	197	0	0
Total ...	1149	685	479

Measurement of the plates for the Catalogue is being systematically carried on with the duplex micrometer mentioned

in the last Report. Both the 6^m and 3^m images are measured and the means taken. During the year 493 quarter plates have been measured, which, with 16 quarter plates measured at the end of 1894, gives 509 quarter plates, equivalent to 127 plates, as the total number measured. The rate of measurement has been increased to about 180 plates a year since October.

The stars in the following portions of the sky have already been measured on each of two plates:—

		h m	h m	
Decl. 65°–66°	R.A.	11 15	− 0 36	
66–67		11 24	− 0 0	
67–68		11 30	− 0 0	(Except $22^h\ 10^m$ − $22^h\ 30^m$)
68–69		19 0	−20 0	

On the 496 quarter plates, which cover these portions of the sky, the images of 17,250 stars have been measured, and of these 13,250 have been measured on each of two plates. The number of stars per plate varies greatly in different parts of the sky. The largest number on any plate completely measured as yet is 664 on the plate whose centre is at R.A. $21^h\ 54^m$ Decl. +66°; and the smallest is 67, on the plate whose centre is at R.A. $2^h\ 42^m$ Decl. +66°.

Towards the determination of the Right Ascensions and Declinations of the stars the following steps have been taken. From the Right Ascensions and Declinations given in the catalogues of the *Astronomische Gesellschaft*, "Standard Co-ordinates" have been deduced for all stars on 72 plates which are contained in these catalogues. By a comparison of these with the measured co-ordinates, plate-constants have been determined, from which the "Standard Co-ordinates" of other stars on the plates may be obtained by means of a linear correction, and the Right Ascensions and Declinations deduced by a trigonometrical transformation, if desired. A full account of this, as well as of the comparison of 30 overlapping plates, is given in the *Monthly Notices*, 1896 January.

Some experiments have been made in the reproduction of the Chart plates, so as to form a map of the portion of the sky from R.A. $19^h\ 0^m$ to $20^h\ 50^m$, and Decl. 64° to 71°. Positives on glass of the 37 negatives covering this region have been taken, and from these platinotype, gelatino-chloride, and bromide card-prints have been made for comparison. From a preliminary examination of these, it seems that the bromide cards are the most suitable, and that on these very few, if any, stars are lost, which is far from being the case with the platinotype prints. The bromide cards have the advantage of not needing to be mounted and rolled, and are very convenient for use.

The Dallmeyer photoheliograph, of 4 inches aperture, now mounted on the terrace roof of the south wing of the new building in the south ground, has been the only instrument employed

for solar photography in 1895, the Thompson photoheliograph not being at present available, in consequence of the progress of the building operations, in the course of which the Lassell equatorial and dome have been dismounted. With the Dallmeyer instrument photographs of the Sun were obtained on 234 days, and of these 482 have been selected for preservation, including 13 with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination. Photographs have also been received from India up to 1895 November 5, and from Mauritius up to 1895 July 25, leaving only one day—1895 January 7—for which no photograph is yet available for measurement in the year ending with the date of the last Mauritius negative received.

The Greenwich photographs have been measured in duplicate up to the end of 1895, and the areas and heliographic positions of the spots and faculæ have been computed. The complete results for 1893 have been printed, and the daily results for 1894 have been passed for press up to April 26 ; the manuscript has been sent to the printer up to May 30, and that for the rest of the year is nearly ready. The measurements and reductions for 1894 proved distinctly heavier than for 1893, although there was a falling off in the mean daily spotted area. This was owing to the number of small groups, and to the great complexity of some of the larger groups. The decline in the spotted area has continued through 1895, and has brought about a slight diminution in the work of measurement and reduction ; the number of volumes of the forms used in the computation of the areas and heliographic positions of the spots being fewer in 1895 by about one-fifth than in 1894, and by about one-tenth than in 1893. The work, therefore, is still very heavy, for on no occasion in 1895 was the Sun free from spots.

The publication of the final results of the Greenwich-Montreal longitude determination has been delayed, owing to the pressure of other work, and the inadequacy of the existing permanent staff.

The transit observations at contiguous stations in the front court, to determine the difference of longitude between them were continued on four nights with the instruments used in the Paris-Greenwich longitude determinations. The observations have not yet been reduced.

Observations were made on the pier of the Transit Pavilion by Captain Burrard, R.E., and Captain Conyngham, R.E., to determine the difference of longitude of Greenwich and Potsdam, in connection with the re-determination of the longitude of Madras. From June 14 to July 1 Captain Burrard was at Greenwich and Captain Conyngham at Potsdam ; they interchanged stations July 11–25, and determined their personal equations at Greenwich May 28–30, and at Potsdam July 30–August 3.

The volume of *Greenwich Observations* for 1893 is printed, with the exception of the Introduction, of which proofs have

been received. The printing of the volume for 1894 is advancing.

Electric lighting was introduced throughout the Observatory, with the exception of the Magnetic Observatory and the new Physical Observatory, last June, and has also been applied successfully to the principal instruments, including the Transit Circle. It is thoroughly satisfactory and economical.

The building of the north wing and completion of the central octagon of the new Physical Observatory, on which the Thompson 26-inch photo-telescope will be erected, was begun in 1894 September. Delays occurred from the severe frost of last spring, and later from failure in the supply of terra-cotta, and the building is not yet quite finished. Meanwhile the Lassell Dome was dismounted by Messrs. Cooke, so that its re-erection can be begun as soon as the building is ready. The Merz Refractor (12·8-inch), which was mounted on the Lassell Equatorial, will be used as a guiding telescope on the Thompson photographic telescope.

There have been no changes in the permanent staff during the year, and the two vacancies among the second-class assistants have not yet been filled up, a scheme for reorganisation of the staff being still under the consideration of the Government.

The Observatory will shortly lose the services of Mr. Criswick, who retires on pension on January 31, after a useful and honourable service of forty-one years at the Observatory.

Royal Observatory, Edinburgh.

During the year 1895 great progress has been made towards the completion of the new Royal Observatory at Blackford Hill. The dwelling-houses have been occupied for several months, and the boundary wall is now nearly finished. The Dunecht 15-inch refractor by Grubb was mounted in the east dome in July and August, and finally adjusted in September, since which time it has been regularly employed in observations of comets, and occasionally of minor planets, but the work has been much interrupted by unfavourable weather.

The sidereal clock by Frodsham formerly at Dunecht has been mounted in a specially prepared clock chamber, together with the standard sidereal clock by Dent, presented in 1855 to the Calton Hill Observatory by Sir Thomas Makdougall Brisbane. The Brisbane clock has been fitted in a cast-iron air-tight case, in which a constant barometric pressure of twenty-five inches is maintained. The clock chamber is in the base of the pier of the large east dome. It is lined with silicate cotton, and is provided with two double doors packed with the same non-conducting material, so that the temperature in the chamber remains nearly constant during long periods. These two clocks are connected with a small chronograph by Fuess, which is mounted

in the chronograph room, under the west dome, and also with a sounder in the experimenting room, by means of which the comparisons with the mean-time clock by Molyneux are made. The Fuess chronograph is provided with two signal levers, so that observations made at any two different instruments can be recorded simultaneously. The large four-barrel chronograph by T. Cooke & Sons is in process of being mounted.

The time service, which includes the working of the time ball on the Nelson Monument, the firing of the time guns at Edinburgh Castle and at Dundee, and the controlling of clocks throughout the city of Edinburgh, was transferred from the old Observatory to Blackford Hill on November 8, and has since been carried on without interruption, the time observations being made with the fine 4-inch reversing transit by T. Cooke & Sons, and the time distributed by the Molyneux clock.

Observations for the determination of the difference of longitude between the old and new Observatories were made by Mr. Heath and Mr. Ramsay on seven nights in the autumn with the 6·4-inch transit instrument at Calton Hill and the reversing transit at Blackford Hill. As at that time there was no telegraphic communication between the two stations, two mean-time chronometers were each night carried to and fro between the Observatories, two journeys being usually made each way. In order to eliminate personal equation, the observers changed stations when about half the observations had been made. The result places Blackford Hill $1^{s}\cdot17$ west of Calton Hill, with a probable error of $\pm0^{s}\cdot05$. The adopted longitude of the transit house at Blackford Hill is $12^{m}\ 44^{s}\cdot2$ west of Greenwich, and of the 15-inch refractor $12^{m}\ 44^{s}\cdot0$.

The workshop, with its lathes and other apparatus, and the large photographic rooms have been in use for some months. The barograph and barometer, the thermometers and rain gauges, were all mounted in good time to begin a continuous meteorological record on 1896 January 1. A monthly return will be made to the Scottish Meteorological Society.

Although work at the old Observatory was given up in November, the rain-gauge record there was continued to the end of the year, when it was taken up by the city authorities, by whom it is now being carried on. The old Observatory has been acquired by the city, the transit instrument, mural circle, and vertical circle having been left there on loan, with the sanction of her Majesty's Government. The weekly readings of the rock thermometers there will however be continued, as before, by one of the Royal Observatory staff. The regular daily readings of the bifilar pendulum at Calton Hill were carried on by Mr. Heath until October 28, when the instrument was removed to Blackford Hill, where it will be remounted along with a similar pendulum vibrating at right angles to it, the pair being arranged to give a continuous photographic record. On June 9 a curious instance of sudden oscillation of the pendulum was observed, and a short

account of it was published in *Nature* of July 4. The total oscillation in the plane of the meridian was 0″·4 of arc to the north and 0″·5 to the south.

The reduction of the observations made by Mr. Heath for the re-determination of the latitude of Calton Hill has been completed. The arithmetic mean of 218 observations gives

$$\phi = +55^\circ\ 57'\ 23''{\cdot}19 \pm 0''{\cdot}04,$$

in exact agreement with Henderson's determination made with the same instrument sixty years ago. Dr. Chandler's reduction to mean latitude was computed from the equation given in the *Astronomical Journal*, vol. xiv. p. 74, but did not sensibly affect the above result or its probable error. It does not appear, therefore, that the observations with the Mural Circle are of sufficient accuracy to show the small periodic changes of the latitude.

The 24-inch Grubb reflector from Calton Hill is in process of erection in the west dome at Blackford Hill, and will shortly be ready for use. The driving clock is being provided by Messrs. Ritchie & Son, of Edinburgh, with maintaining power and electric control. The Transit House is now ready for the Dunecht 8·6-inch Transit Circle, which is still in the hands of Mr. Simms, who has retouched the object glass and made some improvements in the illumination, &c.

Mr. Ramsay has been engaged during nearly the whole of the year in the arrangement and fitting up of the new Observatory, and in mounting the instruments and clocks. He has now practically completed the extensive system of electric wires for the sympathetic clocks and chronographs, by means of which observations made with any of the instruments in the Observatory can be recorded on either of the chronographs. Mr. Ramsay has also, to a large extent, conducted the business correspondence of the Observatory.

In September Dr. J. Halm joined the staff of the Observatory, and has since been in charge of the 15-inch refractor, with which the following observations of comets have been secured: Comet Swift four times, Perrine once, and Brooks nine times. He has also given much time to arranging the books of the Crawford Library, which are now completely accessible, while considerable progress has been made with the books from Calton Hill. Dr. Halm has made some observations with the reversing transit in the prime vertical for the latitude of Blackford Hill, the result being in close agreement with the value $+55^\circ\ 55'\ 28''{\cdot}0$, found by Dr. Becker, which may be safely retained as the provisional latitude of the Observatory.

In spite of the varied work in hand the reduction of the Henderson observations has not been lost sight of, and has made steady progress in the hands of Mr. Heath.

During the year six circulars have been issued, referring to the comets above mentioned. To these circulars valuable contributions have again been made by Mr. A. Berberich, of Berlin.

Royal Observatory, Cape of Good Hope.

Mr. J. Power has been appointed junior assistant *vice* Mr. W. H. Cox, promoted.

The chief feature of the work of the Observatory during 1895, following the policy indicated in last report, has been the progress made in overtaking arrears of reduction and publication.

The Cape General Catalogue for 1885, with its appendices, and the annual results of meridian observations for 1885, 1886, and 1887, have been printed, and during the year have been placed in the hands of astronomers. The annual results of meridian observations for 1888, 1889, 1890, and 1891 have been passed through the press. The manuscripts of the annual results for 1892, 1893, and 1894 are in the hands of the printer, and some of the sheets have been passed for press.

The printing in two volumes of *A Determination of the Solar Parallax and the Mass of the Moon from Observations of Iris, Victoria, and Sappho*, is approaching completion. The part of the work referring to the meridian observations of the comparison stars is by Professor Auwers, that of the discussion of the heliometer observations of *Iris* by Dr. Elkin.

The first volume of the Cape Photographic Durchmusterung, containing the places of 152,000 stars, derived by Professor J. C. Kapteyn from the Cape photographs, between the limits of Declination $-19°$ and $-37°$ (both inclusive), has been passed through the press. The introduction is in the press. The manuscript of vol. ii. of the same work, containing the places of 158,000 stars between the limits of Declination $-38°$ and $-52°$ (both inclusive), is ready for press.

A complete account of the Geodetic Survey of South Africa has been passed through the press, with the exception of the index and general map, which are still in the printer's hands, besides an account of the new Geodetic Survey executed by Colonel Morris, R.E., under the direction of H.M. Astronomer. The whole includes a complete re-reduction of Sir Thomas Maclear's triangulation and a comparison of the astronomical results with the geodetic latitudes, longitudes, and azimuths, computed both with Clarke's and Airy's elements of the Earth. The work has been printed at the Cape for presentation to the Cape Parliament at its next session, and will afterwards be distributed.

The current reductions of meridian observations are advanced as follows :—

The computations of	Mean	R.A.	are complete to	1895	Sept. 3
,, ,,	,,	N.P.D.	,, ,,		Nov. 22
,, ,,	Apparent	R.A.	,, ,,		Sept. 3
,, ,,	,,	N.P.D.	,, ,,		Dec. 31
,, ,,	R.A. corrected for collimation and level only are complete to ...				Dec. 1

Note.—The reductions in R.A. after September 3 were necessarily delayed until the double transits of circumpolar stars observed during the winter months had been discussed, and definitive places formed for determining the azimuth in those seasons when double transits could not be obtained.

The Cape Ten-year Catalogue for the Equinox 1890 is well advanced, and will contain the results of all meridian observations of stars made since 1885 August 24 till the end of 1895, reduced to the Equinox 1890, excepting the circumpolar stars, fundamentally observed in 1895, which will be given in an appendix reduced to the Equinox 1895. All observations to the end of 1894 have been reduced to the common Equinox 1890, and the means have been taken. The corrections for flexure, change of latitude, &c., have still to be made, the mean latitude, refraction, &c., to be discussed, and the corresponding corrections applied.

With the special provision made for the reduction of Sir Thomas Maclear's observations, 1861–70—

The Apparent Right Ascensions have been examined to 1864 December 31;
The Apparent N.P.D.'s have been examined to 1867 August 13.

The star-corrections for 1861–1866 and for 1868 are computed. The tabular places of the Moon corresponding to the instants of transit have been computed for the years 1862, 1863, and 1864.

The observations made with the zenith telescope for aberration and change of latitude are completely reduced to mean difference of zenith distance (north—south), and corrected for screw-error, &c. The results are being finally revised previous to discussion.

With the heavy pressure of other arrear work the heliometer observations for stellar parallax, the heliometer and photographic observations of *Jupiter's* satellites remain unreduced. The occultations observed since 1881 have been partly reduced, and the work will be completed as soon as circumstances permit.

The progress made in overtaking arrears of publication and reduction has been purchased at the severe price of limiting the observing activity of the staff, a policy which H.M. Astronomer has followed with great reluctance, but which was the only alternative one to that of increasing, instead of diminishing, the already large stock of unreduced and undiscussed observations. Mr. Power's appointment to fill a position in the staff which had practically been vacant since 1892 April, has, to a certain extent, relieved the pressure. But in view of past experience and the necessity of making provision for efficient working of the McClean telescope, it is obvious that a substantial increase in the Observatory staff is essential.

During the year 1894 nearly the whole of the observations

for the Cape Ten-year Catalogue for 1890 were completed. It remained to make a series of fundamental observations of circumpolar stars to form an appendix to the Catalogue similar to that attached to the Cape General Catalogue for 1885; the instrument accordingly has been almost exclusively devoted to this work.

These observations naturally occupy much longer time than observations of quicker moving stars, hence a comparatively small number of observations was obtained.

With the transit-circle there have been made :

Number of transits observed	2872
Number of declinations	2240
Determinations of collimation	94
„ level	276
„ azimuth	437
„ run	247
„ nadir	248
„ flexure	48

The following occultations of stars by the Moon were observed :—

Disappearance at the dark limb	8
Reappearances	5
No. of separate phenomena	13

With the zenith telescope : Investigations of the errors of the screw and values of levels and screw have been made in connection with the series of observations for aberration and change of latitude.

There were no comets favourably situated for observation from this Observatory.

Comet *Brooks* was searched for but not found, as no motion was given in the cable message, and attention was chiefly given to sweeping *south* of the position given; but the comet was moving rapidly to the north. The 6-inch equatorial, which alone has an eyepiece of large field, was dismantled at the time, its dome being under repair.

Comet *Perrine* was seen once only, viz. on the morning of December 13, near the eastern horizon, the star *Antares* being visible in the same field. The image of the comet faded in the advancing daylight before the definition was sufficiently steady to permit observations to be made. The image of the star remained bright and observable after that of the comet had become invisible. All attempts to detect the comet near perihelion in daylight were unsuccessful. After perihelion the comet could be seen from Sea Point after sunset, but was hid from the

Observatory by Table Mountain, which cuts off about 8° from the horizon in that azimuth.

With the photographic telescope the following work has been accomplished :—

	No. of Plates Exposed.	Exposures No.	Duration.
Catalogue plates	91	273	6^m, 3^m, 20^s each
Chart plates	367	367	(up to) 60^m
Kapteyn-Pritchard areas ...	61	183	6^m, 3^m, 20^s
Circumpolar plates for Professor Jacoby	16	48	6^m, 3^m, 20^s
Speed, trial and adjustments	14	28	
Plates for light curve of R Velorum...	18	129	6^m
Stars suspected of variability in Kapteyn's discussion of the Cape Photographic Durchmusterung	57*	144	6^m

Of the 367 chart plates exposed, only 240 have been passed as successful. The failures have arisen in part from interruptions by cloud and by bad definition, but chiefly because two successive supplies of plates turned out to be faulty ; so that, though the rejected negatives would be available for purposes of measurement, they are unfit for photographic reproduction for chart purposes.

Of the ninety-one catalogue plates exposed only fifty-five were completely successful.

The state of the work stands as follows :—Of the 1512 catalogue plates assigned to the Cape, 1497 have been successfully taken, so that only fifteen remain to be done.

Of the 756 chart plates (even degrees), 503 have been successfully taken, leaving 253 to be done. There remain also 756 chart plates (odd degrees) to be taken, about which the Permanent Committee has not yet decided whether single, double, or triple images of the stars are to be adopted.

Thirty-four catalogue plates, containing 2557 stars, have been completely measured (diameters included) by two independent observers.

The diameters of the discs of the variable star *R Velorum*, together with those of 9 comparison stars, have been measured for all the plates taken to the end of 1895.

A complete investigation of the Réseau Gautier No. 8 has been made, in which the error of sinuosity of every line at twenty-six points on each line has been determined, and all the errors rigorously discussed and tabulated. The results, in the form of a paper by Dr. Gill and Professor Harold Jacoby, will be communicated to the Society.

* These plates are taken on nights of bright moonlight, &c., when conditions are unfavourable for taking chart plates.

Complete Tables of Reduction for the zones $-41°$ and $-42°$ have been computed.

Much time and thought have been given to points connected with the details of the design of the McClean telescope with its accessories and Observatory. H.M. Astronomer has been in almost weekly correspondence with Dr. McClean, a correspondence which has involved the preparation of many sketches and original designs. Dr. McClean has himself laboured indefatigably on the same work, with the result that the designs for all details of the telescope, spectroscope, and Observatory, with its rising floor and dome, are now completed. The building of the Observatory has been begun, and will be ready for the erection of the dome by 1 March. Dr. McClean has provided a developing-room, a study, and store-room, attached to the new Observatory.

The time-signal service has been regularly maintained.

The meteorological observations made at the Observatory in 1895 have been communicated for publication to the Cape Meteorological Commission.

Cambridge Observatory.

The Catalogue of Zone Stars, undertaken by the request of the Astronomische Gesellschaft, taxed nearly all our resources during the past year. It was judged necessary carefully to examine the co-ordinates of each star with their annual precessions and secular variations ; and, though this was facilitated by tables constructed not many years after the observations commenced, it has involved much time and care. In accordance with the original arrangement, the printing is done in Germany, to secure uniformity in the volumes of this extensive catalogue of stars in the northern hemisphere, and the proofs of the portion assigned to us are always sent hither for correction and revision.

The press-work has been carried on as far as $17^h\ 35^m$ right ascension, and contains 8,350 places of stars.

Besides this, a comparison of these places with the earlier catalogues—chiefly Bessel, Lalande, and Argelander—has been undertaken. More than 4,000 have thus been identified and compared ; giving, in a good many cases, interesting results. In not a few instances there are decided evidences of large proper motion, proved by comparing with ours the places given both in Lalande and Bessel. These and other suspected cases are registered for future observation.

The observations of zone stars during the year number 213 ; made, for the most part, to settle questions or solve doubts that have arisen in the examination of the Catalogue. There are eight observations of stars which had been compared with Gale's Comet, and of course the requisite number of observations for clock and instrumental corrections.

Another volume of the *Cambridge Observations* is passing through the University Press; and it is hoped that we shall soon be in a position to place in the hands of the printers the larger catalogue, which contains the result of each individual observation of every star in our zone.

The Newall Telescope, Cambridge Observatory.

The Newall telescope has been used for observations on 145 nights in the course of the year 1895.

In the early part of the year the work done was chiefly micrometer work, partly in determining accurately the arc value of a revolution of the micrometer screw for use in the reduction of the observations of the inner satellite of *Mars*, partly in the observation of detail on *Jupiter*; with special reference to the motion (i) of small spots on the surface, and (ii) of the surface near the red spot. The observations of the inner satellite of *Mars* have been published in the *Monthly Notices*, vol. lv. p. 348.

Observations of occultations of stars during the total eclipse of the Moon 1895 March 10 were made under exceptionally favourable conditions of atmosphere. The observations have been published in the *Monthly Notices*, vol. lv. p. 334.

At the end of April the new spectroscope, the design of which, as was stated in last year's Report, had been put in the hands of the Cambridge Scientific Instrument Company in the previous summer, was received at the Observatory, and the adjustment was at once begun. The rest of the year has been devoted almost entirely to work with the spectroscope. This work has necessarily been of a preliminary nature, but the photographs obtained in the later months of the year have been increasingly valuable, as the instrument has been got into better adjustment, and the observers have acquired more experience in using it. Among the objects whose spectra have been especially studied may be mentioned the following:—

α Boötis, *α Cygni*, *α Lyræ*, chiefly for adjustment.

α Aurigæ, for the determination of velocity in the line of sight with iron comparison spectrum, to compare with the numerous determinations made at Potsdam.

γ Cassiopeiæ, with special reference to the bright Hγ line, the doubleness of which (first announced by Lockyer, *Proc. R.S.* vol. lvii. p. 173) has been fully corroborated.

α Orionis, with special reference to the bands in the yellow and green.

Orion stars, with Helium comparison spectra.

Venus, with reference to the possible determination of the period of rotation.

Dunsink Observatory.

Owing to the necessity of bringing our catalogue of stars to completion, and to the heavy work of computing the precessions, secular variations, and proper motions, systematic observations with the meridian circle and chronograph have been discontinued during the greater part of the year, and these instruments have been chiefly used for the determination of the clock correction for the time service to Dublin. In November and December, however, Mr. Martin obtained 160 observations in right ascension and declination of the stars with large proper motion referred to in former reports.

The work on this catalogue commenced in 1885, but has been greatly interrupted since the beginning of the year 1888 by other observations with the meridian circle, by the changes which have taken place in the staff, and by photographic work with the "Roberts" equatorial.

The observations of stars with large proper motions are now fully reduced to the epoch 1890, and are almost ready for the press.

In reducing these observations the clock corrections and the equator point of the circle are both deduced from observations of the *Berliner Jahrbuch* standard stars. In general, however, observations of the nadir point are also made by reflexion from a trough of mercury.

The error of collimation of the meridian circle has been determined 28 times during the year, the level error 65 times, the nadir point (by reflexion) 23 times, and the error of runs 4 times. For determining the error of azimuth 20 transits of polar stars have been taken. For the purpose of determining the error of the Dent sidereal clock 295 observations have been made of the R.A. of the *Berliner Jahrbuch* standard stars, and 52 observations in zenith distance of these stars have been taken to determine the equator point of the circle.

In May the "Roberts" equatorial, which had been in Sir Howard Grubb's workshop, undergoing alteration, for almost a year, was re-erected. This instrument had in the interval been supplied with a new equatorial mounting and clockwork similar to those used at Greenwich, the Cape of Good Hope, and other observatories, for work in connection with the photographic survey of the heavens. The clockwork is of Sir Howard Grubb's latest pattern, with electric pendulum control, acting on a sector of 28 inches radius. Above the cross-head of the declination axis the instrument is in the same condition as when it was presented to the Observatory, except for some minor alterations, such as screw adjustments to the eye-piece slides, the illumination of the spider lines, &c. The new clockwork and mounting have, however,

practically made a new instrument of it, and rendered it capable of taking photographs suitable for measurement.

The work of adjusting this instrument, and experiments of various kinds with it, occupied a large number of nights in May, June, and July, and it was not till towards the end of the latter month that systematic photographic work became possible. Since the end of August this instrument has not been in use, owing to the illness of the Director, but during the months of May, June, July, and August 32 plates were taken, representing a total of 80 exposures of various lengths, from a few seconds to 42 minutes. These include—amongst other objects—4 photographs of the Ring Nebula in *Lyra* and six of *η Cassiopeiæ* for a re-determination of its parallax. A good deal of trouble has been experienced in rating the control pendulum, but in every other respect the instrument now performs in a very satisfactory way.

Only a few plates have been measured at this Observatory during the year. In addition to a few plates, measures of which were necessary for getting the photographic telescope into adjustment—according to the method proposed by the Director, and published in the *Monthly Notices* for December 1893—2 plates containing photographs of Encke's Comet, taken by Mr. W. E. Wilson, at Streete, on 1894 November 30, were measured. The position of the comet as deduced from these plates was published in the *Proceedings of the Royal Irish Academy*, 3rd Series, vol. iii. No. 4.

During the early months of the year the "South" equatorial was used for measuring some double stars in connection with a research as to the effect of the colour of a star on the refraction which it undergoes.

Of these, 21 complete observations, consisting of 8 readings of each of the two screws for distance, and 4 or 6 of position-angle, were obtained.

The partial eclipse of the Sun which took place on March 25 was also observed with this instrument.

In October Mr. Charles Martin, late Senior Computer at Greenwich Observatory, succeeded Mr. Arthur E. Lyster, M.A., as assistant to the Director.

The time service to Dublin has been maintained as in former years; and on the first Saturday of each month the Observatory has been open to visitors, and the 12-inch "South" refractor placed at their disposal.

Durham Observatory.

The transit-circle has been used upon eighty-seven nights for determining the positions of a few stars near the pole that have not been observed for many years.

This Observatory being a second-class meteorological station,

the usual observations have been taken every twelve hours and regularly forwarded to the Meteorological Office.

The equatorial has been used chiefly to explain its functions to students and to show the various heavenly bodies.

Glasgow Observatory.

The 6-inch transit-circle by Ertel was remounted during the spring of the year. Of the old instrument, the axis with telescope and circles and the microscopes have been retained, but the bearings of the pivots, the supports of the microscopes, the balancing arrangement, and the end-thrust are entirely new, and have been made by Messrs. Troughton & Simms. The parts that were replaced have been mounted on a table so as to exhibit the former features of the instrument.

In the new mounting the microscopes are in rigid connection with the standard on which the axis of the telescope turns, and the Vs are formed by pieces of gun-metal dovetailed into the cast-iron standards. The Vs admit of no adjustment, as each of the standards is cast in one piece. They were brought into position by levelling three projecting points on the stone piers to which the standards were finally bolted and cemented. Three months after the fixing the error of azimuth and the inclination of the axis were respectively $0^s{\cdot}02$ and $0^s{\cdot}20$.

The fulcrum of the balancing contrivance is on a level with the top of the stone piers. Small electric lamps of 1 candle-power, one for each of the ten microscopes, illuminate the circles, the light being conducted to the circles by means of glass rods polished at their ends. I may add that the accumulators which supply the current are charged by thermopiles.

Although the instrument was ready for use in July, observing was not begun then, as it was found desirable to replace the micrometer at the eye-end of the telescope. The micrometer had not arrived at the end of the year.

To the 20-inch "Breadalbane" Reflector a new driving clock with Russell control and a new sector have been fitted by Sir Howard Grubb. The various parts of the large spectroscope arrived at the end of October, but it has not yet been mounted on the reflector, owing to some faultiness in one of its parts.

During the year experiments on the controlling and the working of electric dials have been made at the Observatory, at the instigation of the Corporation of this city. It is intended to control from the Observatory eight clocks placed at various centres of the city, and these will in their turn work about three hundred street dials in twenty independent circuits.

The staff of the Observatory has been engaged in reducing and tabulating the old meteorological records, which date from 1843.

The time service and the extensive meteorological work have been carried on as in former years.

Liverpool Observatory.

As in former years, the work of the Observatory has consisted to a very large extent in the determination and distribution of time, and in giving assistance to shipowners and chronometer-makers. The regulations put into force by the Mersey Docks and Harbour Board, to which reference was made in the last Report, have to some extent interfered with this work, as shown by the diminished number of chronometers deposited for test. The number is, however, slightly in excess of last year, and it is hoped in course of time the old figures will again be reached.

The meteorological observations have been continued on precisely the same lines as heretofore, and application is frequently made in salvage and collision cases for scientific information connected with the direction and velocity of the wind. The local importance of such matters has led to the examination of the changes in the barometer readings and direction of wind during severe gales, and it is proposed to publish the result with the Annual Report.

Comet observations have been prosecuted whenever possible. Faye's Comet was repeatedly looked for, but never seen with certainty. Those of Encke, Perrine, and Brooks have all been observed, and the results will be communicated to the Society.

The transit instrument has been occasionally mounted in the prime vertical for the determination of the declination of unknown stars with which the comets have been compared. A series of observations has also been commenced on the diameters of the larger planets, but has been much interfered with by bad weather. These observations began with the view of re-determining the value of the screws of the various micrometers, and especially of their errors, but have been extended to consider the effects of variously coloured illumination of the field on the measures themselves.

Courses of lectures have been given regularly in connection with the classes at University College, Liverpool, and opportunities have been given to the students for practical work with the transit instrument and the equatorial.

Radcliffe Observatory, Oxford.

The work at the Observatory during the year 1895 has included the following:—

The Moon was observed with the transit-circle at every available opportunity; and stars whose places were required either for comet comparisons or as a check upon the results of the Radcliffe Catalogue, 1890, were also observed.

The Barclay Equatorial was used during the year to a greater extent than usual.

Observations were made of Comet Encke on January 8, 18, 21, 23, and 25 ; that of January 25 being, as far as information is to hand, the latest observation anywhere taken of this comet during its recent apparition. Observations of Comet Swift (1895 August 20) were made on August 24, 28, September 18, 20, 25, 27, October 17 and 24. The results of these observations have been printed in the *Monthly Notices* (vol. lv. No. 3, vol. lvi. No. 2). These results do not adequately represent the time and labour expended on comet work, for careful searches were made for the above comets on many other nights, and also for Comets Faye, Perrine, and Brooks, but the mistiness of the sky or the faintness of the objects prevented their being picked up with the power of the Barclay telescope.

The magnitude of *Nova Aurigæ* was examined at intervals, but no change was detected during the year.

Venus was examined on four nights with variously tinted screens for reported markings on the disc, but nothing unusual was noted, except that on November 18, at $18\frac{1}{2}^{h}$, a hazy shadow was seen inside the limb, and having apparently nearly the same curvature as the planet's limb. It was considered by the observer as possibly due to contrast between the illumination of the body of the planet and the stronger light of the limb.

The great Nebula of *Andromeda* was also carefully examined. No change was remarked in the large nebula, but the nucleus of the smaller companion nebula was noted as "particularly stellar, as if it were a star surrounded by hazy luminosity," and in contrast to the irresolvable condensation of the larger mass.

Measures of eight double stars have also been made with the Barclay Equatorial during the year.

In conjunction with the heliometer, observations of the occultation of a selected list of stars were made during the total lunar eclipse of March 10. (See *Monthly Notices*, vol. lv. No. 6.)

Considerable attention has been devoted during the year to the early Radcliffe observations made by Dr. Hornsby. The observations of γ *Draconis* with the zenith sector have been reduced and published ; and those made with the quadrants and transit instrument during the year 1774 are in process of reduction, and the results promise to be of very considerable value.

The large crayon drawing of the Moon, bearing the date 1795, made by John Russell, R.A., which has been in the possession of the Radcliffe Trustees for many years, having recently shown some traces of mildew, has been cleaned and reframed ; and photographs have been taken and sent to the Society. (See *Monthly Notices*, vol. lvi. No. 3.)

A volume of the Radcliffe Astronomical and Meteorological Results for the years 1888 and 1889 has nearly passed through the press.

The meteorological observations and registrations have been carried on as usual.

The University Observatory, Oxford.

During the year 1895 the energies of the Observatory have been directed chiefly to the work for the Astrographic Chart. The number of catalogue plates obtained was 337, bringing up the total number of regions photographed to 695.

Eighty-seven plates have been measured during the year. It is hoped that this number may be largely increased in future years, when an additional micrometer has been received from Mr. Simms. The total number of stars measured on these plates is 27,653. A description of the micrometer and methods of reduction are given in the *Monthly Notices*, vols. liv. and lv.

By the kindness of Sir Robert Ball, advance proofs of the *Cambridge Zone Catalogue* (R.A. 0^h-5^h) have been received, and the places brought up from 1875·0 to 1900·0 (2,350 stars) for use in the reduction of the catalogue plates.

Some experiments have been made to test the suitability of paper prints for accurate measurement, with encouraging results (*Monthly Notices*, vol. lvi. p. 28).

Some attention has been paid to the photography of minor planets with a view to the determinations of place or parallax. Nineteen plates, with from two to fifteen exposures on each plate, were taken of the planets *Pallas* (3) and *Eunomia* (15).

One of the *Pallas* plates, with exposures ranging over $5\frac{1}{4}$ hours, has been completely measured, and though the range of parallax factor is not large enough to give a result of any great value in itself, the accuracy of the method is clearly indicated; and it has been demonstrated that the method of reduction by rectilinear co-ordinates makes it possible to obtain a planetary parallax from a photographic plate with very little numerical labour. The plates of *Eunomia* have been only recently obtained, and the measures are not yet complete; but the conditions were much more favourable than for *Pallas*.

At the request of Dr. F. McClean three plates were exposed on the same region with different diaphragms in front of the O.G. of the Astrographic Telescope, the exposures, in numbers 14, 16, and 15 respectively, being arranged to compensate the diminution of aperture; and the plates were sent to Dr. McClean. A general examination of the plates assisted him in deciding some questions relative to the new telescope which he is presenting to the Cape Observatory; but a more complete discussion would be of interest and will be undertaken.

At the request of Mr. Newall, the distance between two stars in the Pleiades, suitable for the evaluation of a micrometer screw, was accurately determined (*Monthly Notices*, vol. lv. p. 419).

The Barclay Transit Circle was returned by Messrs. Troughton & Simms 1895 January, and mounted before the end of that

month. Since then observations have been made of collimation, 166; of level, 176; of polar stars, 80; and of clock stars, 254. Besides these observations, the wire intervals and the values of R.A. and Z.D. screws have been determined. A considerable number of these observations were made by Mr. A. J. Walker, M.A. (New College), who took charge of the instrument during the October Term.

Lectures on elementary mathematical astronomy were delivered in the Hilary and Michaelmas Terms. Owing to the unsatisfactory position of astronomy in the University curriculum, there has been hitherto (during recent years) no demand for more advanced lectures; but a change has been effected during the past year which will, it is hoped, have beneficial results in attracting students to a more thorough acquaintance with the science.

A collection of photographs was lent to the Imperial Institute on the occasion of the Photographic Exhibition.

The arrangements for the eclipse expeditions of 1896 have occupied some time, and will probably claim a good deal of attention in the coming year.

Temple Observatory, Rugby.

The usual scholastic work has been continued during the past year, and this shows a tendency to increase. In original work, the measurement of position and distance of double stars has been continued, but the time left available for this has not been so much as in past years. It is hoped that the spread of astronomical interest amongst the boys will compensate for absence of other work.

Stonyhurst College Observatory.

The routine work of the meteorological and magnetical department has been carried on as usual, and the continuous recorders have been working well.

The new "Stonyhurst Sunshine Recorder," made by Messrs. Newton & Co., has been tested by comparisons with the "Campbell-Stokes" Recorder of the Meteorological Office, and has been found to work very satisfactorily. Some improvements have been suggested in the mechanical construction of the instrument, and have been accepted by the makers.

The instruments for absolute measures of the magnetic elements have been compared with the instruments adopted as standards by the Physical Section of the last meeting of the British Association for the Advancement of Science, with the object of co-ordinating the measures obtained at the several magnetic observatories of the United Kingdom. The results of these comparisons are expected at the next meeting of the same Association.

A partial reduction of the magnetograms to figures has been commenced : to the extent of four readings for each day—viz. maximum and minimum horizontal force and westerly direction, and the measures at 4 A.M. and 4 P.M. This work is well advanced for the past year, and will be extended to previous years, according as time allows.

Drawings of the solar spots and faculæ have been made on nearly all the days on which it was possible without too great an expenditure of time in waiting for clear intervals. And in connection with these drawings, photographs of the H–K. region of the solar spectrum have been taken with the grating spectrograph, in order to observe how closely the double reversals by integrated solar light follow the disturbances of the solar surface.

The spectroscopic experimental work with the Perry Memorial Objective was not completely finished until the end of April. These experiments represent a large number of photographic stellar spectra. But the plates are of no value for measurements, having been taken with thirteen different collimators and seven different camera lenses. Several prisms have also been tried, but not all photographically. The finally adopted arrangement is a slitless spectrograph, of one (or two) direct prisms of three components, with a concave compound collimating lens to bring all the rays between D and *h* parallel through the prism. All the parts of the spectrograph are the work of Mr. Hilger.

A very satisfactory wave curve has been plotted for the one-prism spectrum, and another will shortly be made for the pair of prisms.

A new series of photographs of the spectrum of *β Lyræ* has been obtained, consisting of seventy-seven plates. And of these, thirty-nine, or three good plates for each day of the light period, have been selected for measurement. The measurements were not complete before they were necessarily suspended in favour of the regular work of the Observatory, which is always more pressing in the first months of a new year.

A double series of photographic spectra of the brighter stars has been commenced—viz. with the single prism and with the pair of prisms. A wave-length map of the spectral lines of forty-three of the bright stars, photographed with the old 8-inch objective, was finished early in the year ; but it was not thought well to offer it for publication until a more complete series was finished with the larger light collector.

Dr. Common's Observatory, Ealing.

The work of converting the 5-foot Newtonian Reflector into an Oblique Cassegrain has been in progress during the last year. In order to find the best results further experiments have been carried on, involving the construction of various convex surfaces.

In the workshop two 16-inch plane mirrors have been made for the Cœlostats, for use at the next total solar eclipse, and one 16-inch has been made for the new telescope of the Cambridge Observatory, as well as others of less size.

Beyond some experimental photographs no astronomical work has been done of any importance.

Mr. Crossley's Observatory, Bermerside, Halifax.

The usual astronomical and meteorological observations were made during the year just closed. The *Jupiter* observations up to May have already appeared in the *Monthly Notices.* A $4\frac{1}{2}$-inch photo-visual object-glass by Messrs. T. Cooke & Sons, of York, has been mounted here and carefully tested, visually, with excellent results, proving itself at least equal to a 5-inch object-glass of the usual kind.

Wolsingham Observatory. (Rev. T. E. Espin's.)

The new Observatory was not completed till April, and work was re-started on April 14. The total number of observations of variable stars, and with the spectroscope, is 1,113. The observations of stars with remarkable spectra have been forwarded to the *Astronomische Nachrichten.* This list contains : (1) Nos. 1,058 to 1,179 ; of these 18 are probably of Type IV. ; the observation of 51 stars from Krüger's "Catalog der Farbigen Stenre," and various other objects to a total of 210 ; (2) 132 stars observed as III. ! (3) 458 stars observed as III. or II.—a total of 800 objects.

Observations tending to confirm the variation of the following stars have been made :—

Name.	R.A. 1900 h m	Decl. ° ′	Var.	Type.
EsB 184	6 17·8	+25 4	8·9–9·7	IV.
EsB 189	6 20·3	+19 8	8·8–9·5	IV.
EsB 281	8 49·7	+17 36	6·4–7·9	IV.
EsB 357	12 35·8	+56 23	8·0–8·8	III.
Es 1021	19 42·9	+15 48	8·8–10?	III.?
Es 1169	19 52·4	− 2 11	8·4–?	III.
EsB 679	20 33·4	+17 55	6·0–6·7	III.

Mr. Peek's Observatory, Rousdon, Lyme Regis.

The establishment continues in good working order, and observations have been made on 155 nights, this being rather less than the average number. During January and February on

several clear nights the cold was so intense that the equatorial clock ceased to work, and the dome could not be rotated or the shutter raised. During the latter half of December the sky was almost continuously overcast.

The 6·4-inch Merz Achromatic Telescope has been kept regularly at work on long-period variable stars, and 518 determinations of magnitude have been secured, which is fully the average number.

The Red Star discovered by the Rev. T. E. Espin, 1894 November 30, has been added to the working list, and found to be a long-period variable. The observations show it to have ranged from 8·5 magnitude on January 8 to 10·3 magnitude on August 15, rising again to 7·9 by 1895 December 31.

Transit observations have been taken as often as required.

The lunar eclipse of March 10 was observed under very favourable conditions, special attention being directed to the occultations of the list of selected stars given in the *Companion to the Observatory*. Seven disappearances were secured.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The work of photographing nebulæ and clusters of stars has, as in former years, been pursued, and the following list of the photographs, with exposures of 30 minutes and upwards, is given in continuation of the former lists, the last of which was published in the *Monthly Notices*, vol. lv. pp. 223, 224. The negatives are all available for reference :—

	R.A.	Decl.	Expos.
	h m	° ′	m
Tycho's *Nova* in Cassiopeia	0 16	+63 15	90
Great Nebula in Andromeda	0 36	+40 30	90
Neb. in Cetus	0 38	− 8 48	90
Neb. in Cassiopeia	0 47	+56 2	57 and 75^{m}
Region of γ Cassiopeiæ	0 50	+60 7	90 and 2^{h} 12^{m}
Neb. M. 33 Trianguli	1 28	+30 7	2^{h} 15^{m}
Neb. H I. 152 Piscium	2 2	+10 30	54
Clusters in Perseus	2 11	+56 38	90
Neb. H I. 102 Eridani	2 33	− 7 8	90
Neb. H I. 63 Eridani	2 36	− 8 41	90
Cl. H VIII. 61 Aurigæ	5 1	+36 55	30
Nova Aurigæ	5 24	+30 23	3^{h}
Neb. M. 1 Tauri	5 28	+21 57	60
Cl. H VIII. 26 Geminorum	5 54	+23 18	30 and 60^{m}
Cl. H VIII. 9 Geminorum	6 23	+16 46	3

	R.A. h m	Decl. ° ′	Expos. m
Neb. in Monoceros	6 25	+ 5 0	54
Cl. H VIII. 3 Monocerotis	6 29	+ 8 26	30
Cl. H VIII. 50 Monocerotis ...	6 29	+ 5 26	30
Cl. H VIII. 48 Monocerotis ...	6 32	− 1 22	30
Neb. near 15 Monocerotis	6 35	+10 0	90 : 2h and 3h
Cl. H VIII. 31 Monocerotis ...	6 42	− 3 3	30
Cl. H VIII. 71 Aurigæ	6 42	+41 11	30
Cl. H VI. 2 Geminorum	6 49	+18 9	30
Cl. H VIII. 40 Geminorum	7 1	+27 22	30
Cl. H VIII. 33 Monocerotis ...	7 3	−10 29	30
Cl. H VIII. 36 Canis Majoris ...	7 23	−11 32	30
Cl. H VIII. 11 Geminorum	7 23	+13 59	30
Cl. M. 47 Argûs	7 50	−15 8	30
Neb. H I. 249-50 Ursæ Majoris ...	9 1	+60 42	90 and 3h
Neb. H I. 2 Hydræ	9 5	+ 7 28	90
Neb. H I. 167 Lyncis	9 7	+40 33	90
Neb. H I. 216 Ursæ Majoris ...	9 9	+69 39	77
Neb. H I. 113, 137 Lyncis	9 15	+34 35	90
Neb. H I. 260 Ursæ Majoris ...	9 21	+62 57	90
Neb. H I. 114 Leonis Minoris ...	9 36	+32 20	90
Neb. H I. 61 Hydræ	9 37	− 3 10	90
Neb. H I. 285 Ursæ Majoris ...	9 38	+68 24	90
Neb. H I. 78 Ursæ Majoris	9 41	+72 46	90
Neb. H I. 115 and V. 26 Leonis Minoris	9 43	+33 58	72
Neb. H I. 286 Ursæ Majoris ...	9 55	+69 15	90
Neb. H V. 47 Ursæ Majoris ...	9 55	+56 12	90
Neb. H I. 79 Ursæ Majoris	10 8	+73 56	90
Neb. H I. 283 Draconis	10 17	+75 12	40
Neb. H I. 86 Leonis Minoris ...	10 21	+29 3	90
Neb. H I. 87, 88 Leonis Minoris ...	10 56	+29 0	90
Neb. H V. 46 and M. 97 Ursæ Majoris	11 7	+55 56	4h
Neb. H I. 29 Leonis	11 9	+13 23	78
Neb. H I. 121 Virginis	11 55	− 0 30	90
Neb. H I. 33 Virginis	12 2	+10 58	70
Cl. M. 13 Herculis	16 38	+36 39	30 and 60m
Cl. M. 9 Ophiuchi	17 13	−18 24	30 and 60m
Neb. H VI. 41 Draconis	17 33	+75 48	60
Cl. M. 24 Clypei	18 12	−18 28	60 and 2h
Cl. H VIII. 72 Serpentis	18 22	+ 6 30	40

	R.A.	Decl.	Expos.
	h m	° ′	m
Neb. M. 57 Lyræ	18 49	+32 54	2h
Cl. H VII. 19 Aquilæ	19 2	+ 4 4	60
Neb. in Aquila	19 6	+ 0 52	90
Cl. *h* 2035 Aquilæ	19 11	− 1 6	64
Cl. H VIII. 21 Anseris	19 23	+24 56	50
Cl. H VI. 38 Aquilæ	19 26	+ 9 0	60
Cl. *h* 2046 Vulpeculæ	19 36	+26 34	60
Cl. *h* 2048 Cygni	19 37	+39 56	60
Stars in Cygnus	19 45	+35 30	60
Cl. *h* 2053 Draconis	19 46	+59 10	60
Cl. H VII. 9 Vulpeculæ	19 46	+22 50	60
Cl. H VII. 59 Cygni	19 59	+43 37	60
Cl. H VIII. 56 Cygni	20 19	+40 27	60
Cl. H VII. 8 Cygni	20 30	+27 58	60
Neb. H V. 15 Cygni	20 41	+30 20	67
Cl. H VIII. 76 Cygni	20 51	+46 53	60 and 2h
Neb. H V. 14 Cygni	20 50	+30 50	1h 37m
Neb. H I. 52 Equulei	20 56	+15 47	40 and 90m
Region about ξ Cygni	21 1	+43 31	63 and 90m
Cl. *h* 2107 Cygni	21 7	+45 15	60
Cl. H VI. 32 Cygni	21 27	+51 7	60
Cl. H VII. 52 Cygni	21 28	+46 38	90
Cl. M. 39 Cygni	21 28	+47 58	60
Neb. in Cepheus	21 35	+56 59	2h 48m
Nova Cygni	21 37	+42 18	2h
Cl. H VII. 66 and Neb. H IV. 75 Cephei	21 42	+65 27	2h 5m and 3h
Cl. *h* 2141 Cephei	21 55	+54 19	60
Neb. H II. 240 Pegasi	23 58	+15 33	2h 49m

Seven photographs of the eclipse of the Moon on March 10 were taken, and during totality the full disc, with some details, are shown on the plates, and upon two of them the trails of τ (and *comes*) *Orionis*, both at disappearance and at reappearance, are visible. Trails of other stars down to $9\frac{1}{2}$ magnitude are also shown.

Considerable time has been occupied in the investigation of the relative efficiency of the 20-inch reflector and of portrait lenses in the delineation of celestial objects, and a report upon the results obtained is prepared and may be submitted to the Society.

The Earl of Rosse's Observatory, Birr Castle.

During the past year the determinations of lunar heat have been resumed, as opportunity afforded, with somewhat improved apparatus. No opportunity, however, has occurred for observing during a lunar eclipse.

Some experiments in astronomical photography have been proceeding. Great difficulty has been experienced in these from obscuring of the apparatus during prolonged exposures, but these hindrances have at last been overcome. In our uncertain climate, however, the opportunities for long exposures are not many. There has probably been at least an average of clear sky during the year, but an unusually large proportion of this occurred during the summer months, when no observing was going on.

The meteorological observations have been continued as usual.

Mr. Wilson's Observatory, Daramona, Streete, Westmeath.

During the past year a number of experiments have been carried out, and are still in progress, to find out the best method of detecting when a slight shift takes place in the 24-inch mirror on its supports when the telescope is used for long-exposure photography. This defect, to which all reflectors are more or less liable, is the most serious drawback against their use for stellar photography as compared to refractors.

During the spring the 24-inch was used by Professor Minchin with his photo-electric cells to determine the electromotive force of the light of some of the stars. The results have been published in the *Proceedings of the Royal Society*, vol. lviii. The experiments on the radiation of heat from Sun-spots have been carried on by means of the large heliostat. The spots have greatly diminished both in size and number during the year. A 4-inch photo-heliograph has been mounted, and a solar photograph is taken at the time that the solar radiation is being measured, in order that a permanent record may be kept of the positions and sizes of the spots. Some fine negatives have been obtained by its use.

The weather has been very cloudy, particularly during the latter part of the year.

Hongkong Observatory.

Hourly observations and continuous meteorological records, weather forecasts, storm warnings, investigations of typhoons, magnetic observations, and the public time service have been continued as usual. Eleven annual volumes have now been pub-

lished, and the twelfth volume is progressing. Observations of shooting stars have been made by the Director, and sixty-three radiants, many of them southern ones, have been determined. With the Lee Equatorial, double stars have been observed by the Director, the angles with the old wire micrometer, and the distances with the spherical crystal; but this instrument has seen its best days, and there is no dome over it, so that it has to be dismounted in bad weather. It is intended to bring the orbits of double stars calculated at Markree up to date, and correct the elements by the method of least squares. A commencement has been made with *α Centauri* and *γ Virginis*, and the observations of all the stars in question contained in books in my possession have been tabulated. Double-star observers are invited to forward their observations either in printed form or in manuscript.

Madras Observatory.

As for several years past, the work of the Observatory has been confined as far as possible to the reduction and publication of the old observations.

Considerable progress has been made with the General Star Catalogue, and the mean places for 1875·0 have been deduced for the first four hours.

The investigation of the circle errors, begun last year, has not yet been completed, as it was found necessary to send the microscopes home to have the screws, which were much worn, replaced by new ones. This has now been done, and the work is again in progress.

During the year the Government Astronomer drew up detailed plans, in consultation with astronomers at home, for the new Kodaikanal Observatory, and in October the foundation-stone of the Observatory was laid by H.E. Lord Wenlock, but the buildings have not made much progress.

The Government of India having accepted, as a trust, the G. V. Jugga Row Observatory, at Vizagapatam, a committee has been appointed to administer the trust, and the Government Astronomer has the supervision of the astronomical work. The principal instruments at the Observatory are an excellent 6-inch equatorial and a small photographic telescope. No regular observations have yet been begun, but it is intended, as soon as the instruments have been put in good order, to undertake comet work as a special subject.

Natal Observatory.

The work of the Natal Observatory during the past year has been mainly routine work, the Astronomer having been absent on leave in Europe for the greater part of the year.

The new Tables of the Moon, forming a supplement to Hansen's Tables, are being computed, the data on which they are compiled serving to bring the tables into harmony with observations during the entire period 1680–1894, the errors of short period being almost completely eliminated.

Sydney Observatory.

During 1895 the usual work has been carried on with the meridian circle. The weather has, however, been exceptionally bad. Bush-fires have been very prevalent during August, September, and October, owing to the drought and strong winds; hence the smoke has been so thick that the horizon was often not more than a mile distant. Cloud also has been very abundant, and only 96 nights have been clear.

Meridian Circle.—With the meridian circle 1,488 transits have been taken, 408 of these being transits of the Sun, and the remainder of stars. Eight hundred and fifty-three north polar distances have been observed. Fifty-three of these were stars specially selected by Sir Charles Todd with a view of making a new determination of Australian latitudes. In this work we have taken a part with Melbourne and Adelaide. The remaining stars are reference stars for our photographic zone.

Azimuth of the meridian circle has been determined 85 times.

Collimation	299
Level	373
Nadir	363

A series of observations to determine the flexure of the meridian circle has been commenced. Fifty-four determinations have been made, and so far confirm the old value. The computations of 1895 observations are well advanced. The Government printer has not found time to publish another volume of the meridian work, which is waiting for him.

Equatorial.—Owing to cloud, smoke—already referred to—and visitors, only 64 evenings were available for the measurement of double stars. Fifty-eight have been measured. In doing this 751 settings for position-angle and 831 for distance have been made. Five stars supposed to be double have been carefully examined several times without detecting companions. The occultation of *Antares* by the Moon was observed in both phases and the results published.

Star Camera.—At the end of 1894 only 70 plates required to be taken in order to complete those for catalogue stars in our zone. Of these 59 have been taken; the other 11 were passed by accidents of cloud and weather. The total number of photographs of stars taken during the year is 502. Of these 381 are

chart plates, 59 catalogue plates, and 58 for various purposes —the investigation of star clusters and the retaking of a number of catalogue plates which were taken two or three years since, the object being to see if the same number of stars would be found on both sets of plates. Reference has already been made to the weather as the cause of the short amount of work; it has, however, told more on the star camera than on the other instruments, because there were many hazy nights, when the stars could be seen, but not photographed, the reason being that in long exposures the haze reflects enough of the city light to fog the plates. Half an hour is the exposure given to chart plates in good weather, but this has been extended in hazy weather or unsteady definition. A few special observations were made to determine the actual amount of motion in the star images on nights of bad definition. Some nights were so bad that a double star distance 6″ could not be divided with the large equatorial; the two looked like one spot of light. On a good night this telescope will readily divide a pair at distance 0″·5. Photographic star discs are enlarged by this motion in the atmosphere; frequently they were three times as large in diameter as they ought to be. The light was therefore distributed over nine times the surface, and took nine times as long to photograph; so that a star of the 11th magnitude, which on a good night is photographed in one minute, would take nine minutes; and practically it is found that satisfactory photographs of stars cannot be obtained upon nights of such bad definition. It being impossible to take chart plates whenever the Moon is at all bright, the photographer has been engaged in making lantern slides of star groups, with great success. They are the finest I have seen.

Zone Time.—Zone time was adopted in this colony on 1895 February 1—that is, the time of the meridian 150° of longitude east of Greenwich.

Meteorology.—The meteorological work has been carried on as usual—a large increase in the number of observers, and a corresponding expansion of the work.

General.—During the year 4,600 copies of various publications have been distributed. These are chiefly meteorological, but include the chart of circumpolar stars, &c.

Visitors.—The number of visitors to the Observatory persistently increases, and is becoming a very serious tax upon the staff. The majority come to see the Observatory in the daytime; the others come at night, and are a still more serious difficulty, for the telescope had to be given up to them on thirty-one nights. The total number is 1,050. In addition to these, 459 persons came to see me personally on business connected with the Observatory, and 123 letters asking for information have been received, to answer which occupied the time of one clerk 187 hours. However much this tax on the time of the Observatory staff is to be deplored, it is at present impossible to avoid it.

Mr. Tebbutt's Observatory, The Peninsula, Windsor, New South Wales.

Although much cloudy weather was experienced at both the beginning and the end of the year 1895, a fair amount of work was accomplished. The local sidereal time was determined on 184 nights, and for this purpose 957 transits of stars with a declination not exceeding 40° were observed. The determinations of the level, collimation and azimuth errors of the transit instrument were 454, 52, and 159 respectively. The level and azimuth errors have undergone great progressive changes during the year. Relatively the eastern pivot fell slowly from the beginning of the year till towards the close of February. From that time it gradually rose till about March 23; but subsequently it fell till the end of the year, and it was found necessary to raise it by adjustment no fewer than fourteen times during that period. The north end of the axis of collimation moved persistently westward throughout the year, and at the close the azimuth *west* had attained to nearly a minute of arc. When the steadiness of the instrument for some years past is taken into consideration these changes are remarkable. The behaviour of the standard sidereal chronometer has been satisfactory, the mean daily gaining rate being 3·05 seconds.

In the extra-meridian department the following work has been done. Sixty-four phases of lunar occultations of stars have been observed, comprising thirty-five disappearances at the dark and ten at the bright limb, and fourteen reappearances at the dark and five at the bright limb. Twelve *Nautical Almanac* stars, of which *Antares* on May 10 was one, were observed in both phases. B.A.C. 6127, a star of the 5th magnitude, was well observed with the 8-inch telescope in both phases, and in full sunlight, on August 29. The details of this interesting observation are given in the *Observatory* for 1895 November. During the past thirty-two years 691 occultation phases have been observed, and the year 1895 presents the greatest number secured in any one year during that period. The thanks of myself, and astronomers generally, are due to Mr. Joseph Brooks, F.R.A.S., the officer in charge of the local trigonometrical survey, for his kindness in providing the Observatory with prediction calculations of occultations for the year. The series of observed occultations for 1873–76 was used some years ago by Dr. Auwers for the determination of a fundamental meridian for Australia. The series for 1864–70 is now in the hands of another astronomer for a similar purpose, and it is hoped that the much longer series for 1877–95, which has been obtained with better instrumental means, will leave little to be desired in the way of data for the determination of Australian longitude.

Filar micrometer comparisons of *Jupiter* and 1 *Geminorum* were made on the 8-inch equatorial on January 5 and 10. Similar comparisons were made of *Saturn* with κ *Virginis* on May 6, 7, 9, 13, 15, 16, and with 96 *Virginis* on August 4, 8, 9, 10, 11, 12. The minor planets *Ceres* and *Hebe* were also compared micrometrically with neighbouring stars on fourteen and eleven nights respectively, the former in pretty high south declination, and the latter at the request of Dr. Luther, of Düsseldorf.

In consequence partly of the want of ephemerides, but mainly of the cloudy state of the skies in December, nothing was seen of the comets discovered by Perrine and Brooks. A brilliant comet was reported to be visible in the south-west at several places in Victoria and South Australia, but no chance was afforded here for getting a view of the stranger. It probably passed quickly into the northern hemisphere.

Observations of the phenomena of *Jupiter's* satellites were made in February, March, April and May. The earliest visible eclipse of the fourth satellite for the current cycle was partly observed on April 11, the reappearance occurring $13^m\ 17^s$ before the time given in the *Nautical Almanac*.

Measures of seventeen well-known southern double stars have been made, comprising forty-five nights, 815 settings for position-angle, and 348 for distance. The results for α and γ *Centauri* and γ *Coronæ Australis* have been sent to Dr. See, of Chicago, and those of α *Centauri* to Dr. Doberck, of Hongkong, in accordance with applications from those astronomers.

η *Argûs* was examined on a few occasions and a well-connected series of comparisons of *R Carinæ* was obtained, from which it appears that the maximum of this variable was attained on May 13, $=5{\cdot}1$ of the magnitude scale of the *Uranometria Argentina*. This was brighter than the maximum of 1894 by half a magnitude, and is the eleventh satisfactorily determined at Windsor since 1879. A comparison of the Cordoba observations in 1871 with those at Windsor in 1895 gives a mean period of about 311 days from maximum to maximum. This is a day less than that deduced from the comparisons down to 1886.

The meteorological observations have been regularly made during the year, and the last winter proved to be the coldest experienced at the Observatory for thirty-three years. The abstracts for 1891–92–93–94–95 are now nearly ready for the printer.

Finally, all the astronomical observations and their reductions have been made by the proprietor, and nearly all the meteorological observations, with their reductions, have also been made by him.

Lovedale, South Africa. (*Mr. A. W. Roberts's.*)

The work here has been the observation of variable stars south of −30° Decl. The systematic search for short-period variables carried on in previous years was given up in 1895, as the number of known variables had so increased that only the regular observation of such stars could be undertaken.

Two new variables, however, were discovered, one in *Crux* and the other in *Vela*. The stars *X Carinæ* and *R.S. Sagittarii* were proved to be of the Algol type. The former star was discovered at Lovedale and the latter at Cordoba, by Dr. Gould.

Observations were made on 114 nights, the particulars being as follows :—

Algol variables (4 stars)	901
Short-period variables (17 stars)	1296
Regular long-period variables (16 stars)	594
Suspected variables (15 stars)	102
	2893

Each of the above observations is the mean of two, one direct and the other reverse. This mode of observation has been adopted to eliminate "position error."

As each observation also means, on the average, the determination of five comparison stars, the individual determinations of magnitude throughout the year are considerably over 30,000.

The position of the Observatory is—

Long. $1^h\ 47^m\ 24^s{\cdot}5$ E.

Lat. $-32^\circ\ 46'\ 30''$

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1895.

Twelve new planets were discovered during the past year, as follows :—

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1895.	Discoverer.	Place of Discovery.
BP	399		Feb. 23	Wolf	Heidelberg
BQ	...		23	„	„
BU	400		Mar. 15	Charlois	Nice
BT	401	*Ottilia*	16	Wolf	Heidelberg
BW	402		21	Charlois	Nice
BX	403		May 18	„	„
BY	404		June 20	„	„
BZ	405		July 23	„	„
CB	406		Aug. 22	„	„
CC	407		Oct. 13	Wolf	Heidelberg
CD	408		19	„	„
CE			Dec. 9	Charlois	Nice

It is possible, however, that CE may be identical with (188) *Menippe*.

The following planets, discovered in 1894, but not numbered at the date of the last Report, have since received permanent numbers :—BE 391, BF 392, BG 393, BH 394, BK 395, BL 396, BM 397, BN 398. BD, BO, do not receive permanent numbers, not having been sufficiently observed. (318) has been named *Magdalena*, (319) *Leona*, (331) *Etheridgea*, (336) *Lacadiera*, (369) *Aëria*, (384) *Burdigala*, (392) *Wilhelmina*. The unappropriated number 330 has been assigned to 1892 X, discovered by Wolf 1892 March 18. The planets provisionally named BR, BS, BV, CA, CF, CG, were found to be identical with (379), (333) *Badenia*, (203) *Pompeia*, (336) *Lacadiera*, (352), (175) *Andromache* respectively. (403) has an orbit somewhat resembling that of the missing planet (156) *Xanthippe*, and was at first supposed to be identical with it. A systematic search was made for (132) *Aethra*, but without success. The period of (401) *Ottilia* is almost

exactly half that of *Jupiter*, which will make the theory of its motion interesting.

Mr. B. M. Roszel has recently published an investigation of the total mass of the first 311 minor planets (*Johns Hopkins University Circular*, 1895). He uses Mr. Barnard's measures of *Ceres*, *Pallas*, and *Vesta*, and assumes that the remaining planets have the same albedo as *Vesta*, the mean density of the group being assumed the same as that of *Mars*. He thus determines the mass of the group as ·003 of that of *Mars*. On the more probable assumption that the mean albedo of the group is only $\frac{1}{3}$ of that of *Vesta* (*vide* Mr. Barnard's paper, *Monthly Notices*, vol. lvi. p. 2) the resulting mass would be about ·008 of that of *Mars* or $\frac{1}{14}$ of that of the Moon.

General Parmentier has published an analysis of the distribution of the orbits of the first 390 minor planets (*Bulletin of the Astron. Soc. of France*, 1895 March). The four smallest mean distances are (330) dist. 2·09, (323) *Brucia* 2·16, (149) *Medusa* 2·17, (244) *Sita* 2·17. The three largest are (279) *Thule* 4·26, (361) 3·96, (153) *Hilda* 3·96. The gaps at distances corresponding to $\frac{1}{2}$ and $\frac{1}{3}$ of *Jupiter's* period still persist, though the planet (401), since discovered, occupies the first-mentioned gap. There is a less strongly marked gap at a distance corresponding to $\frac{2}{5}$ of *Jupiter's* period. But gaps formerly noted at distances corresponding to $\frac{2}{7}$ and $\frac{3}{7}$ of *Jupiter's* period have been filled by recent discoveries, and can no longer be said to exist. The greatest density of the group is at distance 2·80, exactly that indicated by the law of Bode or Titius. *Ceres*, *Pallas*, and *Juno* all approximate to this distance. Of the 390 orbits discussed, 384 have mean distances between 2·16 and 3·48.

The following planets, discovered previously to the end of 1893, have been observed at one opposition only :—99, 132, 155, 156, 157, 188, 193, 220, 285, 290, 293, 296, 307, 309, 310, 314, 315, 316, 319, 320, 323, 327, 328, 330, 332, 339, 340, 341, 342, 343, 353, 355, 356, 357, 358, 359, 360, 361, 362, 364, 365, 367, 368. All the other planets from 1 to 378 inclusive have been observed at two or more oppositions.

The following planets, discovered in 1894, have already been observed at two oppositions :—379, 380, 381, 384, 387, 389. 396 is probably identical with a planet discovered by Palisa on 1887 April 21, but not numbered at that time.

During the year ending 1895 November, Professor Wolf found that of the planets registered on his plates one was new for every 6·3 that were known. During about the same period M. Charlois photographed one new planet for 4·0 known planets. These figures suggest that the number of planets brighter than the 14th magnitude still to be discovered is not very large ; too much stress, however, must not be laid on this expectation, since six new planets have already been discovered during the first three weeks of 1896.

A. C. D. C.

The Comets of 1895.

The year 1895 has not been rich in either cometary discoveries or observations. At the beginning of the year the very faint comet of Swift was still visible in some of the larger telescopes, but though observations are very scanty, it is hoped that the later positions may decide the interesting question of the identity of the comet with that of De Vico, 1844, I. Encke's comet was also visible, but was soon lost by its approach to the Sun.

The first cometary discovery of the year is due to Professor L. Swift, of Echo Mountain, California, who, on August 20, detected a faint comet in *Pisces*. For a short time after its discovery it increased slightly in brilliancy, but always remained an inconspicuous object, and was not generally observed after October. But the observations are sufficient to establish not only the fact of its periodic character, but to indicate a possible connection with the well-known comet of Lexell. The most accurate orbit yet published is probably that from M. Schulhof, but in this the uncertainty in the period (7·19 years) amounts to fifteen days. It is evidently too early to express an opinion, and the question is further complicated by the close approach which the comet can make to both *Mars* and *Jupiter*. The distance between the orbit of *Mars* and that of the comet is less than 0·007 R in longitude 15°, while in longitudes 179° and 135° the orbit is separated from that of *Jupiter* by 0·08 R and 0·24 R. respectively. With an inclination of only 3° such approaches must be anticipated. In 1886, however, if Schulhof's elements are trustworthy, the comet and *Jupiter* were distant from each other by less than half the distance of the Earth from the Sun, and the orbit of the former must have suffered severe perturbation. A comparison between Schulhof's elements and the elements which Lexell's comet may, very possibly, have had after the excessive perturbations of 1779 is given below.

	Swift's Comet.		Lexell's Comet.	
Long. of Perihelion ...	338°·1	Eq. 1895·0	337°·7	Eq. 1770
„ Node	170·3		167·1	
Inclination	3·0		4·9	
Excentricity	0·6515		0·6782	
Semi-Axis Major	3·724		3·874	
To which may be added as a matter of interest,				
Tisserand's Criterion ...	0·493		0·480	
Long. of closest approach to ♃	179·5		184	

The one condition unfavourable to the assumption of identity between the two comets is the slight alteration in the longitude of the node. With the small inclination that this comet has, the

retrogression of the longitude of the node should be considerable, and can only be explained by the suggestion that the node has really retrograded through 357°. Unfortunately, the period and the position of the orbit are such that no return favourable for observation can be expected before 1931, and to settle this question with certainty and to ensure its re-discovery with confidence the period should be known with an error of not more than one day. It is questionable whether the observations secured at this appearance possess the necessary accuracy.

The next comet to be noted was that of Faye, which, however, does not actually reach perihelion till March of this year. As the chances of observing it in the autumn of 1895 were favourable, a finding Ephemeris was prepared by Dr. Folke Engström, which led to its detection at the Nice Observatory on September 26 by M. Javelle. At this date the theoretical brilliancy was about a maximum, but the alteration in brightness is very slow and gradual. The few observations that have been made have been confined to the larger instruments, and in these with difficulty. The perturbations do not seem to have been rigorously computed for this return, but are slight. The effect on the period is less than five days.

A bright telescopic comet was discovered on November 17 by Mr. Perrine, of the Lick Observatory, in the morning sky and approaching the Sun. The increase in brilliancy was very considerable, but its close proximity to the Sun prevented the comet being seen under the best conditions. It became visible to the naked eye, and in the telescope the tail could be traced for a degree in length. In the southern hemisphere the conditions for seeing and observing were somewhat better than in Europe. It passed its perihelion on December 18 at less than one-fifth of the Earth's distance, and owing to this tolerably close approach has remained too near the Sun for post-perihelion observation. Owing to a rapid movement northward, however, it may possibly be seen in February, but the brilliancy will only be about one-sixth of that at the discovery. The motion can be represented by a parabola.

The last cometary discovery of the year is due to Mr. Brooks, of Geneva, who, on the morning of November 21, perceived a comet low down in the south, but moving into a more favourable position. The elements show that the perihelion passage had taken place a month before the discovery. The comet was then not well situated for observations in the northern hemisphere. The discoverer described the comet as bright, but European observers generally have found it faint and difficult to follow. Its great northerly declination has been of assistance in securing a good series of observations, and it is still possible to observe it in powerful telescopes. The motion appears to be parabolic, but attention has been called to the fact that the elements closely resemble those of the comet of 1652, as shown below.

	Brooks' Comet (Berberich).	Comet of 1652.
	° ′	° ′
Long. of Perihelion	298 46	300 11
„ Node	86 6	91 33
Inclination	76 15	79 28
Log. least distance from ⊙ ...	9·9259	9·9279

The observations of the comet of 1652 are deserving of a new discussion.

To this notice might be added the fact that both Barnard's Comet, discovered in 1884, and that of Brorsen, have passed perihelion within the year without being observed. The former was expected in June, but the maximum theoretical brilliancy was only about twice as great as that at the time when the comet was last observed in 1884. Except it be rediscovered by accident, its chance of future observation is slender. Brorsen's Comet, supposing it to be moving in the orbit in which it was last seen, approached the Sun in August, an unfavourable time of the year for perihelion, since at the time of greatest brilliancy the comet is near the Sun.

W. E. P.

Progress of Meteoric Astronomy in 1895.

January Meteors.—On the evening of 1895 January 1 Mr. Corder, at Bridgwater, saw only 8 or 9 meteors (including 2 or 3 *Quadrantids*) between $6^h\ 15^m$ and $10^h\ 45^m$, but the sky was partly cloudy. At Bristol 5 meteors were recorded during a watch of two hours before $8^h\ 20^m$. At the latter place the sky was pretty clear during most of the time of observation. The expected display of *Quadrantids* failed to present itself but in very meagre form. Two of the meteors, which appeared on January 1, were seen both at Bristol and Bridgwater—at $6^h\ 43^m$ a *Quadrantid* of the 3rd magnitude fell from a height of 58 to 47 miles over N. Wales, and at $7^h\ 24^m$ a slow *Eridanid* of the 2nd magnitude fell from a height of 65 to 50 miles over S. Wales. The radiant of the former was at 233°+56°, of the latter at 62°−12°.

April Meteors.—On the nights of April 17, 19, 21, 23, and 24 Mr. Blakeley, at Dewsbury, in watches extending altogether over 10 hours, saw 45 meteors, including 23 *Lyrids*. The radiant seemed at 270°+36° on 19th, 274°+36° on 21st, and 280°+35° on 23rd and 24th. The several positions suggest a rapid displacement to the eastward. Mr. Corder observing on April 19, between 11^h and $15^h\ 15^m$, counted 27 shooting stars, of which 15 were directed from the region of *Lyra*. The most brilliant ones and several others make a definite radiant at the usual position, 274°+34°, but the rest could not be brought into conformity with this point, some of them being directed from about 8° N. and some 10° E. of it. A few meteors of the April epoch

were also observed by Professor A. S. Herschel at Slough, and by the writer at Bristol. Three of the most brilliant of those recorded were fortunately seen at more than one station, and their heights and radiants were as follows :—

1895.	Time.	Mag.	Height at Beginning.	Height at Ending.	Length of Path.	Radiant Point.
April 14	11 44	1	87 miles	71 miles	107 miles	$316^\circ + 31^\circ$
19	10 59	1 – ♀	91 ,,	43 ,,	97 ,,	$269 + 30$
19	11 46	1	77 ,,	70 ,,	40 ,,	$300 + 20$

The second in the list was a brilliant *Lyrid*, well observed at four stations. It was estimated as $2 \times ♃$ by Mr. Blakeley at Dewsbury, and as = ♀ by Mr. D. E. Packer at Birmingham.

August Meteors.—Moonlight partly interfered with observation, but otherwise the conditions were favourable. Between August 7 and 11 Mr. Corder noted 134 *Perseids*. Mr. Blakeley recorded 46 during watches on clear nights from August 2 to 14, and at Bristol between August 7 and 11, 29 *Perseids* were mapped. Professor Herschel found the *Perseids* scarce from $10^h\ 50^m$ to 12^h on August 7, for though the sky was cloudless only 4 meteors were seen. On August 11 Professor Herschel watched a clear sky from $9^h\ 50^m$ to 12^h, and recorded 26 paths, the great majority of them being *Perseids*. The following radiants were determined :—

Aug. 2	$35^\circ + 55^\circ$	16	E. R. Blakeley
7	$39 + 53$	11	,,
7	$40 + 56$	...	H. Corder
7	$41 + 57$	5	W. F. D.
10	$45 + 55$	17	,,
11	$43 + 58$	...	A. S. Herschel
11	$43\frac{1}{2} + 58$	...	H. Corder
11	$44 + 58$	7	W. F. D.
11	$45 + 56$	13	E. R. Blakeley
14	$51 + 58$	6	,,
18	$51 + 56$	...	H. Corder

The easterly motion of the radiant is well indicated from these observations, but the shower was neither a numerous nor a brilliant one. Professor Herschel found the radiant very diffuse on August 11, and Mr. Corder describes it as very scattered and indefinite. Six of the meteors recorded between August 7 and 11 were observed at more than one station, four of them being *Perseids*. The other two were from radiants at $45° + 47°$ (*α Persei*) and $333° + 36°$ (*1 Lacertæ*) representing well-defined minor showers of the August period.

October Meteors.—Mr. Blakeley observed 11 *Orionids* between October 16 and 23 from a radiant at 90°+14°, and a contemporary shower of unusual activity had its centre east of *a Ceti* at 47°+4½° (10 meteors). The latter forms a well shower of slow meteors; it was seen in 1869 by Lieut.-Colonel Tupman on October 14 at 44°+4°, by the writer at Bristol, in 1879 on October 20 at 45°+6°, and in 1886 on October 22 at 43°+5°. On October 16 Mr. Corder registered 6 *Orionids*, and determined the radiant as at 91°+15°. The shower could not be well traced, for though the Moon was absent from the sky cloudy weather prevented much observation.

November Meteors.—It was expected that the *Leonid* stream might exhibit increased activity in 1895, as we had arrived comparatively near the time of maximum, but though the sky was attentively watched the results proved the display to have been of an ordinary character, such as that which occurred in 1879 or 1888 when the parent comet (*Tempel I.* 1866) was not very far removed from aphelion. The following is a summary of observations:—

Date. 1895.	Hours of Observation. h m	h m	Duration. h m	Meteors Seen.	Leonids.	Observer.
Nov. 12	14 5	to 16 30	2 25	18	3	Corder
12	15 15	17 0	1 45	7	2	Herschel
13	9 40	13 0	3 20	14	1	Riggenbach
13	10 30	13 0	2 50	...	11	Booth
	14 0	14 20				
13	11 0	13 30	2 30	10	2	W. F. D.
13	11 30	15 40	4 10	34	16	Blakeley
13	12 10	15 10	3 0	18	7	Herschel
13	14 0	16 10	2 10	26	11	Corder
14	12 40	14 25	1 45	10	2	Herschel
15	11 45	12 40	55	...	1	Blakeley
16	12 15	13 30	1 15	...	1	,,
16	16 15	18 15	2 0	22	12	Corder
17	14 0	17 0	3 0	30	8	,,

Radiant Point.

151°+23°	9 meteors	Herschel
154+23	34 ,,	Corder
154+24	11 ,,	Booth
150+23½	16 ,,	Blakeley

Very brilliant *Leonids* were seen by Mr. Blakeley on November 13 $13^h\ 50^m$, about $\frac{1}{4}$= ☽, and on November 16 at $12^h\ 32^m$, about $\frac{1}{2}$= ☽. The latter was followed in 11 minutes by a very per-

ceptible detonation. One noteworthy feature of the display in 1895 was its extended duration, for it still maintained a decided activity as late as the morning of the 18th, according to Mr. Corder's observations.

Contemporary with the *Leonids*, the *Taurids* formed the chief display among the many minor showers. Mr. Corder noticed about 20 of them, and found the radiant at $58°+22\frac{1}{2}°$. Mr. Blakeley also recognised this stream, and placed its radiant at $59°+22°$. He saw other showers at the same period, among them being radiants at $45°+21°$ (*Arietids*) and $51°+44°$ (*α Perseids*). Like the *Taurids* and *Arietids*, the latter furnishes slow meteors. It is a well-marked November shower, and was first seen in 1879 November 12–14 by the writer, when its radiant (D. 767) was placed at $48°+43°$.

December Meteors.—On December 10 Mr. Corder, watching until midnight, counted 31 meteors. On December 11, between $13^h\ 45^m$ and 18^h he recorded 88, so that they were fairly numerous. He remarks that few of those seen belonged to the companion radiant of the *Geminids*, near *β Geminorum*, at about $119+29$. Mr. Blakeley, watching on December 12 until 12^h, saw 24 *Geminids* from a radiant at $108°+33°$. Mr. W. E. Sperra, writing from Randolph, Ohio, U.S.A., says: "An unusual number of bright shooting stars were noticed this morning (December 13) radiating from a point near the zenith, or somewhat south of it." (*Popular Astronomy*, iii. p. 270.)

Fireballs.—On the night of March 10, while observers were watching, in the clear frosty air that prevailed, the varying phases of the total lunar eclipse, two fine meteors burst into view. The first was noted at $14^h\ 27^m$, and appears to have been witnessed by many persons. A comparison of the various descriptions shows that its radiant point was in *Cepheus* at $330°+59°$, and near that of the detonating fireball of 1894 January 25 (see *Monthly Notices*, vol. lv. p. 238). It descended from a height of 50 miles above Llandilo to a height of 23 miles above a point east of Lundy Island, and traversed a path of 58 miles with a velocity of about 19 miles per second. Its apparent brightness was variously estimated, according to the distance of the observers, as $=$*Sirius*, $=\mathfrak{U}$, and $=\mathfrak{P}$. At Cardiff it was seen as a magnificent fireball falling in the western sky, and leaving a long trail of coloured sparks. The second meteor appeared at $15^h\ 24^m$, and was well observed at London, Reading, and Brighton. Its radiant was in *Draco* at $240°+63°$, and the meteor seems to have fallen almost vertically towards the Earth's surface. It was 80 miles high when first seen, and 40 miles high when it disappeared. Its position was above the Isle of Wight. These deductions are not quite certain, as the observations are not satisfactorily accordant.

On June 10 a large fireball was seen by Messrs. Booth and Townshend at Leeds, and by Mr. D. E. Packer at Birmingham. At Leeds its brightness was estimated as $5\times\mathfrak{P}$, and its diameter

as $30' \times 8'$. At Birmingham it was rated at 4×9. The meteor fell from 58 to 44 miles over the N. of England, and its real length of path was about 89 miles. Its radiant was at $259° - 23°$ between *Scorpio* and *Sagittarius*. This region of the ecliptic furnishes the radiants of many large meteors during the summer months.

On July 7, at $10^h\ 49^m$, a beautiful double-headed fireball was observed from many parts of the country. It moved with extreme slowness, but its path has not been determined with well-assured accuracy, for the meteor appeared in a sky brightly lit with the rays of a full Moon, and few stars were visible by which to fix its apparent course. The radiant point appears to have been at $217° - 6°$, and the meteor fell from a height of 53 to 30 miles, beginning over a point near Bath, and terminating its visible career over Birmingham. It had a length of path of 79 miles, along which it travelled with a velocity of about 9 miles per second. The head of the meteor was formed by a double nucleus, separated by an interval of about 530 yards.

On November 14, at $6^h\ 30^m$, a very interesting, though by no mean brilliant, meteor was seen by Mr. Corder at Bridgwater, and by Messrs. Davis and Saunder at Crowthorne, Berks. It moved with remarkable slowness from a radiant point at $319° - 9°$ near β *Aquarii*, which is a more westerly position than that of any shower ever observed in the month of November. The meteor fell from a height of 49 miles over Ringwood, Hants, to a height of 29 miles over Easton, Wilts, and its Earth point was 8 miles W. of Banbury, Oxon. Its real length of path was 40 miles.

Perhaps the most brilliant fireball of the year appeared on November 22 at $6^h\ 51^m$. At Bristol and other places, where the sky and stars were veiled in cloud, the meteor illuminated the firmament with startling intensity, and many people mistook it for lightning. The observations of its path at the few places where the object was displayed in a clear sky are not sufficiently definite to enable the real path to be determined.

Several very large meteors were casually observed in May, June, and December, and in November an unusual number of these bodies appeared on various dates.

The report for 1894 of the Meteoric Section of the British Astronomical Association was published in 1895 June, and contains a summary of useful facts relating to recent observations. There is a list of 98 radiants determined in 1894, also tables of brilliant meteors and some interesting particulars as to the real paths of a few of these bodies.

In *Astronomische Nachrichten*, No. 3,306, Dr. W. Doberck gives a list of 28 radiants of shooting stars recorded at the Observatory, Hongkong, chiefly in the autumnal months of 1891 and 1892, and the author expresses his intention to continue the work. On one ground, however, we are sorry to take exception to the catalogue of radiants furnished by Dr.

Doberck. A considerable number of the positions are deduced from only two or three meteor paths, and are therefore extremely uncertain. It is most undesirable that radiants of feeble showers (already very numerous, and in many instances doubtful) should be adopted on evidence of such slender character. It seems to us that to fix a radiant with anything like accuracy at least five meteors are necessary, except in special cases.

Among the papers published on meteoric astronomy during the year may be mentioned one in the *Monthly Notices* for December last, giving a summary of observations of the October meteors (*Orionids*) which indicate that the radiant is stationary amongst the stars during the three weeks over which the display extends.

W. F. D.

Total Solar Eclipses.

There have been no total solar eclipses of importance during the last two years, but several reports of the one on 1893 April 15–16 have been published.

M. Deslandres, who was deputed by the Bureau des Longitudes to observe the eclipse, and stationed himself at Fundium on the Salum River, where also was one of the English parties, has published accounts of his results (*Comptes Rendus*, 1893 May 15 and 1895 April 1).

M. Deslandres's attention was specially directed to two points. Firstly, to measure the rate of rotation of the corona; and, secondly, to photograph the ultra-violet region of the corona spectrum. The former was attempted by the method of observing the relative displacement of the green "corona" line—when the spectra of two regions of the corona, at opposite sides of the Sun, were placed in juxtaposition. A grating spectroscope was employed, and from the measurements made during the eclipse the conclusion was arrived at, that the corona partakes of the Sun's rotation. Without in any way impugning the skill of M. Deslandres, it is obvious that such a difficult observation must be repeated before it can be accepted as conclusive. The ultra-violet corona spectrum was attacked in the usual manner with a photographic spectroscope furnished with quartz lenses and an Iceland spar prism. A photograph was obtained showing the continuous corona spectrum and superimposed upon this a number of faint bright lines. Forty of these lines were measured between λ 3090 and λ 3629, the great majority of which do not coincide with the lines of any known element. The intensity of the corona spectrum was found to fall off rapidly in the ultra-violet, as would naturally have been expected. Dr. Schuster showed some time ago that the point of maximum intensity of the corona spectrum, as compared with that of the Sun, is shifted considerably towards the red.

Mr. Schaeberle's report on the result obtained by him at

Mina Bronces, Chili, has been published (*Contributions from the Lick Observatory*, No. 4).

The principal work that Mr. Schaeberle set himself to accomplish was to photograph the corona on a much larger scale than had before been attempted. To this end a Clark objective of 5 in. aperture and 40 ft. focal length was mounted on a fixed pier, and the slide carrying the photographic plate on another pier, a canvas tube which was in actual contact with neither of the piers, extending between lens and plate. The slide carrying the plate was the only moving part, and its motion was so regulated by means of inclined planes as to give it the same velocity and direction as the Sun's focal image during the eclipse. With this instrument some very beautiful photographs were obtained, showing the prominences and lower corona with a definition which leaves little to be desired. Copies of these photographs have been presented to the Society, and one has been included in the list of photographs available for distribution, copies of which can be purchased by Fellows.

Mr. Schaeberle is of opinion that the appearance of the corona at this eclipse is a strong confirmation of his, now well-known, mechanical theory. By this theory the rays and streamers of the corona are explained as being streams of matter ejected from disturbed regions on the Sun's surface, and moving in elliptical streams, one focus of the ellipse being at the Sun's centre.

As regards the English observations, the results obtained are rather in the direction of continuity of record than of actual novelty. As is well known, the eclipse was successfully observed by two parties, the one at Para Curu, Brazil, and the other at Fundium in Africa. A splendid set of photographs was obtained at both stations. The spectroscopic results as yielded by the objective prism and by the slit spectroscopes have been reduced by Professor Lockyer and Captain Hills respectively, whose work has been published by the Royal Society. (*Phil. Trans.* 185, p. 711, and *Proc. Roy. Soc.* 56, p. 20.)

The drawing of the corona, combined from all the photographs, has not yet been published, but the photographs have been examined sufficiently to show that there was no perceptible alteration in the form of the corona as seen at the two stations, *i.e.* at an interval of one and half hours.

Professor Thorpe measured the photometric intensity of the corona, but his results have not yet been published.

This year an important total eclipse occurs on August 9, and it is hoped that well-equipped English parties will proceed to both ends of the line of totality—viz., Norway and Japan. The Eclipse Committee are arranging to send four observers to Japan, who will occupy two stations as widely separated as possible, and four observers to Norway. Besides these there will doubtless be many astronomers who will take advantage of an eclipse visible at such a short distance from England, and should

favourable weather be obtained, there is no doubt that the phenomenon will be better observed than it has ever been hitherto. E. H. H.

Solar Activity in 1895.

The solar activity, so far as it is represented by the numbers and areas of Sun-spots, has continued to decrease throughout the year 1895, as throughout the preceding one. But the decline has been very slow, the Sun showing a considerable number of groups on most days, though there have been no great displays like those of 1893 August and December, or of February and the early summer of 1894. At the Lyons Observatory M. Guillaume recorded only twelve naked-eye spots during the first nine months of the year, as against twenty such in the twelve months preceding.

The chief groups of 1895 were observed in March, the early part of August and of October, and the latter part of December; whilst in the beginning of July, at the end of the first decade of October and of November, and at the end of the first week of December, the spots were very few and small. Still, no day throughout the year was entirely free from spots, the last example of the kind having occurred on 1891 March 28.

The decline in number and area has been much more marked in the southern hemisphere than in the northern, the reverse having been the case in 1894, so that now the spots are on the whole pretty evenly distributed between the two, the balance on the whole being in favour of the North. The same even distribution holds good for faculæ, which, M. Guillaume finds, have diminished in mean area about one-fourth. The decline in the mean latitude of spots has been only small; indeed, M. Guillaume's observations indicate a slight recovery in the northern hemisphere during the first three quarters of the year, though, as Professor Tacchini notes, no spots and few faculæ attain a higher latitude than 30°.

Solar Spectroscopy.

Spectroscopic observations of the Sun during 1895 indicate a general, though very slight, decline in activity as regards the ordinary prominences. Professor Tacchini's results for the first half of the year show a well-marked minimum in January, but after that a relative increase in mean daily numbers.

All the observations agree in showing the northern hemisphere to have been more active than the southern, reversing the order of things prevailing since 1892; this change being brought about by the entire suppression of the southern high latitude zone of activity, which in 1894 completely enveloped the south pole. Another feature in the prominence distribution

clearly brought out by the observations both of Professor Tacchini and the English observers is the sharp limitation of the active prominence forming zones within the parallels $\pm 55°$; prominences in higher latitudes having been quite insignificant in number and in size.

Metallic prominences seem to have been relatively numerous, judging from the observations of Mr. Evershed, who finds about 5 per cent. of the prominences seen by him reversing the sodium and magnesium lines, whilst he only found 1·3 per cent. in 1894, observing in each year about 1,000 prominences altogether. This observer also states that the corona line (λ 5316) has been relatively more frequent in the chromosphere.

Eruptive prominences have been very rarely seen. Professor Hale records one on March 25, $9^h\ 50^m$ to $11^h\ 6^m$ Chicago mean time. This, however, seems to be the only large one seen during the year. Professor Hale was fortunate in obtaining some very fine photographs of the phenomenon by means of his large spectrograph with moving slits, adjusted on the K line. From measurements of his plates he deduces the maximum height of the prominence at 624″.

Publications of the Astrophysical Observatory of Potsdam, vol. x.

The first part of the tenth volume, No. 32, of the *Publications of the Potsdam Observatory* bears an especial interest to solar physicists as containing the last published observations of Professor Spörer, late Chief Observer there. They consist of tables giving the position-angles, heliographic longitudes, longitudes from the central meridian, and heliographic latitudes of groups of Sun-spots, in the form of a ledger for each rotation of the Sun. Descriptions of the groups are added as foot-notes, and the whole embraces a period of nine years, from 1884–1893, which covers roughly the interval between two maxima of spotted area with the included minimum. Two series of charts at the end of the volume illustrate the ledger, one series giving a representation of the entire spot display of the Sun, rotation by rotation; the other showing the distribution of the several groups in heliographic latitudes. The coexistence of two widely separated regions of disturbances is very evidently indicated in the chart for the minimum of 1889–1890. In 1889 the groups are at first clustered closely on the equator, but in the last seven rotations of the year spots appear in very high southern latitudes; and as the equatorial spots disappear, groups in high northern latitudes are also seen. In 1890 and 1891 the equatorial spots become fewer, and are separated by long intervals of time; but the high latitude spots are numerous, and evenly distributed in time in the southern hemisphere, and by 1891 are preponderantly numerous in the high north. In the Introduction, Professor Spörer explains the methods of observation. Weather

permitting, Dr. Lohse each day took photographs, which were utilised, together with Professor Spörer's eye-observations, in obtaining the positions of the spots. The plates were measured until 1891 by Dr. Wilsing, and later by Herr Roller. The advantages of the direct observation methods over the photographic are, according to Professor Spörer: (1) on many days when no exposure can be given direct observation of spots can be made in breaks in the clouds; (2) when the sky is covered with a thin veil or mist only faint pictures of larger spots can be obtained, but telescopic observations at the same time can better identify the spots and allow measures of their places to be taken, and the brief moments of better seeing can be utilised; (3) for small spots, as in the case of stellar plates, an independent check is necessary to prevent the measurement of defects of the plate.

No. 33 is the volume containing the meteorological observations for the years 1888–1893, made under the direction of Professor Kempf.

Helium.

The discovery of the substance giving rise to the bright "helium" line, D_3, of the solar chromosphere and prominences was a sequence of the discovery of argon. Professor Ramsay, in his search for possible sources of argon, had his attention drawn to uraninite by a paper by Dr. W. F. Hillebrand "On the Occurrence of Nitrogen in Uraninite, &c." (*Bull. of the U.S. Geol. Survey*, No. 78, p. 43). The particular mineral employed by Professor Ramsay was clèveite, essentially a uranate of lead, from which he derived –by boiling with weak sulphuric acid––a gas which, when carefully freed from impurities and, so far as possible, from all known gaseous bodies except argon, gave in its spectrum not only the lines of argon but the long sought for D_3 line.

Professor Ramsay describes his discovery in a paper entitled "On a Gas showing the Spectrum of Helium, the Reputed Cause of D_3, one of the lines in the Coronal Spectrum," dated 1895 March 26, and read before the Royal Society. Several vacuum tubes were filled with the gas and their spectrum compared with that of argon thrown simultaneously in the field. "It was at once evident that a new gas was present along with argon. The comparison of the spectra showed a brilliant line in the yellow in the clèveite gas, nearly, *but not quite*, coincident with the sodium line D of the argon tube."

"Mr. Crookes was so kind as to measure the wave-length of this remarkably brilliant yellow line. It is 587·49 millionths of a millimetre, and is exactly coincident with the line D_3 in the solar chromosphere, attributed to the solar element which has been named 'helium.'"

Other sources of helium than clèveite were sought for, and it appears that it is retained by minerals consisting of salts of

uranium, yttrium and thorium. Hitherto the uraninites, clèveite and bröggerite, have been the minerals mostly drawn upon, but monazite, a phosphate of cerium, lanthanum, and thorium, has been suggested by Professor Ramsay as a more economical source.

The laboratory study of the new gas was at once begun and its low density demonstrated. In a paper appearing in the July number of the Journal of the Chemical Society, Professor Ramsay gives its density as 2·13. It is thus the lightest of all known substances after hydrogen. The ratio of its specific heat at constant volume to that at constant pressure is high, viz. 1·632. Its solubility in water is the lowest recorded for any gas, from which it is inferred that the boiling point of liquid helium is very low. Chemically it is, like argon, most inert. "Both resist sparking with oxygen in presence of caustic soda ; both are unattacked by red-hot magnesium ; and, if we draw the usual inference from the ratio between their specific heats at constant volume and at constant pressure, both are monatomic gases. These properties undoubtedly place them in the same chemical class and differentiate them from all known elements." If argon and helium are both monatomic elements, their atomic weights would be respectively 39·8 and 4·26.

The examination of the spectrum of the new gas realised the expectation, to which the apparent identification of its principal line with D_3 had given rise, that many of the previously unexplained lines of the chromosphere would find in it their counterparts. In a paper appearing in the *Comptes Rendus* of the Paris Academy of Sciences April 16, Professor Clève published Thàlen's measures of six lines, which thus corresponded to six leading chromospheric lines—λ 6677, D_3, 5048, 5016, 4922, 4714. The first of these lines was confirmed by Professor Lockyer in a paper read April 25 before the Royal Society—the first of a series of studies of the spectra of the gases from uraninite. M. Deslandres communicated the wave-lengths of twenty helium lines to the Paris Academy on May 20, and carried the identification of the chromospheric lines still further, amongst them being the line at λ 4472, Lorenzoni's *f*, and later observations have brought out still more correspondencies.

A serious difficulty in the acceptance of the identification of the new gas with solar helium arose when Professors Runge and Paschen found on photographing the spectrum of the former with a concave grating of 6·5 metre radius that the yellow line which it gave was double, and composed of a strong line of wavelength 5875·883 tenthmetres on Rowland's scale, and a much fainter companion, distant from it 0·323 tenthmetres towards the red (*Nature*, 1895 June 6, vol. lii. p. 128). As up to that time the chromospheric line had always been accounted to be really single—though an apparent duplicity, supposed due to the superposition of a telluric line, is on record it was not until Professor Hale and Dr. Huggins had severally succeeded in

detecting a faint companion to D_3 in the prominence spectrum that the presence of true helium in the clèveite gas became established.

The further study of the spectrum by Professors Runge and Paschen brought out a number of most interesting peculiarities, of which they give an account in a paper appearing in the *Proceedings of the Berlin Academy* of 1895 July 11, and, later, in articles in *Nature* for September 26, and the *Astrophysical Journal* for 1896 January. Since Balmer gave, in 1885, a simple formula for connecting the wave-lengths of the lines of hydrogen, a formula verified in 1890 by Professor J. S. Ames in his careful determination of the wave-lengths of the lines in the ultra violet, many metallic spectra have been found, especially by Professors Kayser and Runge, to be similarly of a strictly rhythmical character, though with these the lines form three series, two of which tend to approach the same limit, whilst the lines of hydrogen form one series alone. Professors Runge and Paschen having determined the wave-lengths of the numerous lines given by the clèveite gas, many of which are close doublets, with the utmost delicacy and refinement within the reach of the most powerful modern spectroscopic appliances, succeeded in resolving the spectrum, so irregular at first sight, into a combination of singularly perfect sequences. "We have investigated," they say, "the spectrum of the gas discovered in the mineral clèveite by Ramsay, and have found it to be most regular. It consists of six series of lines, the intensity of the lines in each series decreasing with decreasing wave-lengths." Of these six series two approach one limit, and two another; the two stronger series of lines being both composed throughout of double lines, the components of which are separated from each other by a constant oscillation frequency, whilst the two weaker series consist of single lines throughout. With each of these pairs of series a third is associated. "We thus get two spectra consisting of three series each, two series ending at the same place, and the third leaping over the first two in large bounds, and ending in the more refrangible part of the spectrum. . . . Each of our two spectra now shows a close analogy to the spectra of the alkalies. We therefore believe the gas in the clèveite to consist of two, and not more than two constituents."

The scale on which the photographs were taken, from which these determinations of wave-length were made, may be inferred from the fact that the average distance apart of the centres of the components of the various doublets was, for the ultra violet, but one-seventh of a tenthmetre; the refinement of the measures from the fact that this distance, as measured, differed from that computed on the assumption of equal differences of oscillation frequency, only by two or three thousandths of a tenthmetre on the average. The great power and precision of the instrument employed have thus enabled a suspicion raised by Professor Ramsay to be set at rest, viz. that the clèveite gas had several

lines in common with argon. These more delicate measures showed that some of the argon lines were, indeed, near some of the helium lines, but were quite distinct from them.

Analogy with the relations which Professors Kayser and Runge have worked out in the spectra of the alkalies has led Professors Runge and Paschen to suggest that the distance apart of the several components of the clèveite pairs may afford an index of the atomic weight of one of the constituents. If so, the atomic weight of the gas in the spectrum of which D_3 occurs will be between 5·2 and 5·7, and it follows that the other constituent which is supposed to exist in clèveite must be considerably lighter.

This view, that the gas from clèveite really consists of a mixture of two gases, of which the one—the heavier constituent presumably—gives a spectrum in which the D_3 line is most conspicuous, and which is therefore the true solar helium, whilst the spectrum of the other is characterised by the green line at λ 5016, appears to be confirmed by the following considerations.

The supposed "lighter constituent," which Dr. Johnstone Stoney suggests should be called "parhelium," appears to be transmitted through a plug of asbestos more rapidly than the true "helium," for after such diffusion D_3 and its associated lines decrease in brightness relatively to λ5016 and its companions. The inference is not, however, beyond objection, for a similar result is obtained by a simple diminution of pressure; and further experiments with larger quantities of the gas are needed. This alteration in the relative brightness of the spectra of the supposed two gases has been noted not only in the regions of the spectrum explored by the eye and the photographic plate, but also in the infra-red. Theory indicated that the initial line of each of what have been called the two principal series should be found in this region, and accordingly exploration with the bolometer revealed two strong lines in the predicted places far below the visible limit of the red end of the spectrum. And under the influence of change of pressure these lines varied relatively to each other, just as the lines of the two spectra in the visible region do.

Of the six strongest lines of the clèveite gas spectrum, three, viz. λ 7066, 5876 (D_3) and 4472, are given the frequency number 100 in Young's table of the chromospheric lines; whilst those at λ 6678, 5016 and 4922 have the numbers respectively 25, 30, and 30. The first three lines belong to the true "helium" spectrum, the last three to that of "parhelium." Both Professor Lockyer and M. Deslandres had independently expressed their opinion that the clèveite gas was not a simple one, but a mixture, from the commencement of their study of it, basing that opinion on the difference in behaviour of the different lines corresponding to it in the chromosphere.

In Nova Aurigæ, the "lighter constituent" was represented by two very strong lines, λ 5016, and 4922, and apparently by a

third, λ 6678 ; but "true helium," if at all, by only λ 5876 and 4472, both very weak.

On the other hand, a decidedly larger proportion of the lines of "helium" appear to have been recognised in the spectra of nebulæ than of those of "parhelium."

The view, therefore, that the gas obtained from clèveite is really a mixture, of which helium is one constituent, has much in its favour, if it cannot yet be said to be fully established.

The curious, and as yet unexplained, peculiarity of the lines of helium, that like D_3 they are not seen as dark lines in the ordinary solar spectrum, does not hold good for all stellar spectra. A large number of the lines of both spectra have been found by Professor Vogel in *β Lyræ*, and in ten of the principal Orion stars. And besides these, so high a proportion as 25 out of 150 of the brighter first type stars show them, besides 4 stars in which the *Orion* line, λ 4472, was discovered by Dr. Scheiner. This discovery has led Professor Vogel to revise his classification of star-types ; and Class I. *b* is now defined as consisting of spectra showing, with the still dominant hydrogen lines, the lines of clèveite gas ; whilst Class I. *c* is divided into two subdivisions, according as the bright lines seen are those of hydrogen lines alone, or of hydrogen, helium, and some of the metals.

The *Wolf-Rayet* stars, Vogel's Class II. *b*, have as yet yielded only four of the helium lines ; the solar stars, Class II. *a*, and the banded spectra, Classes III. *a* and III. *b*, appear not to show them at all.

The lines of argon have not been observed as yet in any celestial spectrum, but the examination of the gas derived from some meteoric iron from Augusta County, Virginia, has shown Professor Ramsay not only the presence of helium, but of that of argon likewise ; indeed, the latter appeared to be much the more abundant.

Heliometer Determinations of the Solar Parallax and Mass of the Moon.

From the report of the Cape Observatory it will be seen that a volume dealing with the heliometer work organised by Dr. Gill, and in great measure carried out by him personally, is nearly completed. Preliminary accounts of some of the results have been published (*e.g.* in the *Monthly Notices* for 1894 April ; and in Professor Newcomb's "Astronomical Constants"), and these are sufficient to show the excellence of the work and to intensify the interest with which the publication of the volume is expected. It seems advisable, however, to defer any account of these results until the next report, when the work will have appeared in its complete form.

Astronomical Papers of the American Ephemeris.

The papers of this important series published during the past year are Newcomb's *Tables of the Sun*, *Tables of Mercury*, and *Tables of Venus* (vol. vi. parts 1, 2, and 3), and Hill's *Tables of Jupiter* and *Tables of Saturn* (vol. vii. parts 1 and 2). As the publication of the solar and planetary tables (the end and aim of the researches on which Professor Newcomb has been engaged for many years) has so far advanced, it seems a fitting opportunity to review, as briefly as possible, the inception and progress of the work now approaching completion.

Fortunately for this purpose, Professor Newcomb has recently published a monograph, "The Elements of the Four Inner Planets and the Fundamental Constants of Astronomy," which gives a summary of the work on which he has been engaged for the last eighteen years, and indicates the more important of the results to which he has been led.

It must be premised, however, that the work of the revision of the theories, and construction of the tables, of *Jupiter* and *Saturn*, was assigned to Mr. G. W. Hill. The result of this division of labour has been the introduction of a certain amount of diversity in the data and methods employed, which will necessitate a separate reference to Mr. Hill's work later on.

"The diversity in the adopted values of the elements and constants of astronomy is productive of inconvenience to all who are engaged in investigations based upon these quantities, and injurious to the precision and symmetry of much of our astronomical work." These words give the keynote to Professor Newcomb's endeavours to derive improved values of the fundamental elements, and to embody them in new tables of the celestial motions. The necessary conditions laid down by Professor Newcomb are that such tables shall be founded upon uniform elements and data, and that the results of employing the adopted elements shall be carried out with all necessary precision. Granting these premises, it is not difficult to show that even Le Verrier's work—great as it was in relation to the astronomy of quarter of a century ago—leaves much to be desired in the way of attainment of uniformity in adopted astronomical data. So that his work, though making a greater epoch in astronomy than that of any of his immediate successors can be expected to make, does not wholly supply the wants of science in the immediate future. Professor Newcomb points out that similar objections apply to his own table of *Uranus* and *Neptune*.

Guided by these considerations, Professor Newcomb resolved to devote all the available force at his command to this very important undertaking. The preliminary researches are published in five volumes of the series of papers. The solar tables, as mentioned above, form vol. vi. part 1.

The first step in such a work obviously consists in the reduc-

tion of observed positions of the Sun and planets to a uniform equinox and system of declinations. This was effected by means of the Catalogue of 1098 Standard Clock and Zodiacal Stars (vol. i. part 4), in which the right ascensions are those of Newcomb's fundamental equatorial stars, and the declinations those of Boss. These are, however, eventually corrected by means of the observations of the Sun and planets. The tabular elements adopted for correction were those of Le Verrier's tables. It was however, found necessary to apply corrections to the geocentric places deduced from these tables to reduce them to a uniform system of masses. In the determination of corrected solar elements it was considered advisable, in view of the systematic errors affecting the observations of the Sun, to combine them with observations of the inner planets, when these were favourably placed for the purpose. The results of transits over the Sun's disc also enter largely into the finally adopted corrections in the case of *Mercury* and *Venus*. The transits of *Mercury* are discussed in vol. i. part 6 of these papers; those of *Venus*, in 1761 and 1769, in vol. ii. part 5. For the results of the transits of *Venus* in 1874 and 1882 Professor Newcomb depends entirely on the heliometer measures and photographs of the German and American expeditions.

Professor Newcomb's attention was attracted to a singular discordance among the residuals of the normal equations for *Mars* for different periods. On examining into the matter, he was led to the conclusion that the theoretical value of the coefficient of a certain long period term in the mean motion of *Mars*, depending on the action of the Earth, and having for argument $15g' - 8g$, was not determined with sufficient accuracy. It was decided, therefore, to make an approximate empirical correction to the theory, as the work on which Professor Newcomb was engaged could not wait for a new determination of the coefficient referred to. M. Leveau has, however, recomputed the coefficient of the inequality in question (*Bulletin Astronomique*, tome xii. pp. 507–515), and finds an exact accordance with Le Verrier's result. It appears, therefore, that the anomalies, to which Professor Newcomb has drawn attention, must be referred to some other cause.

The masses of the planets having been determined by methods independent of the secular variations, and the resulting computed secular variations having been compared with the values deduced from observation, some considerable discordances (besides the well-known motion of the perihelion of *Mercury*) were brought to light. Various hypotheses, referring to the action of unknown masses or arrangements of matter, are discussed by Professor Newcomb with regard to their adequacy to account for these discordances. The hypothesis most favoured by him is that propounded by Professor Hall in the *Astronomical Journal*, vol. xiv. p. 7, to the effect that the gravitation of the Sun and planets is not exactly as the inverse square of the distance.

Assuming that the exponent of the distance is 2·0000001612, it is found that the motion of the perihelia of the four inner planets can be well represented. In the result, Professor Newcomb decided to increase the theoretical motion of each perihelion by the same fraction of its mean motion (*i.e.* ·0000000806), a course which will represent the observations, without committing him to any assumption as to the cause (though it agrees with the result of Hall's hypothesis), and to adopt for the elements what he calls "compromise" values between those reached by the solution of the equations of condition, and those which would exist if there is abnormal action of the kind suggested. By this procedure the outstanding discordances are reduced within narrow limits.

An independent test of Hall's hypothesis is, as Professor Newcomb points out, very desirable. The most favourable case, for such a purpose, is obviously that of the Moon, where the motion of the perigee would be accelerated, under the assumed conditions, by about 140″ per century. The theoretical motion has not yet, however, been determined with sufficient accuracy to decide the point. And, as a matter of fact, the observed motion of the perigee, and of the node, when compared with Hansen's theory, give results, the one favourable, the other unfavourable, to the hypothesis in question.

An important part of Professor Newcomb's plan consisted in the adoption of uniform and consistent values of the fundamental constants of astronomy. In the monograph on "Elements and Astronomical Constants," referred to above, these subjects are fully discussed. In speaking of the constant of precession, Professor Newcomb is careful to point out the important bearing on the subject of the now generally recognised difference of "personal equation" in the observations of the right ascensions of faint stars compared with those of bright stars. The constant of precession not being so closely connected with other constants that a small error in its determination will seriously affect general conclusions, being nearly eliminated through the proper motions of the stars, or the motions of the planets in longitude, Professor Newcomb merely combines some of what he considers to be the best determinations. Of these, the one he considers entitled to most weight is L. Struve's "Bestimmung der Constante der Präcession." The value of the annual general precession in longitude for the epoch 1850, to which he is thus led, is 50″·2371.

The mean value of the constant of nutation, which Professor Newcomb adopts, is 9″·214 for 1850.

The doctrine of the interdependence of the constant of aberration and that of solar parallax through the relation that the aberration is equal to the quotient of the velocity of the Earth in its orbit by the velocity of light is accepted by Professor Newcomb: "Its simplicity and its general accord with all optical phenomena are such that it seems to me it should be accepted, in the absence of evidence against it." His "compromise" value

for the solar parallax being 8″·790, the corresponding value of the constant of aberration is 20″·501.

The value of the principal coefficient of the lunar inequality which Professor Newcomb deduces from observation is 6″·465. The observations made use of for this purpose are (1) all the observations of the Sun's right ascension from early in the century to 1864 ; and (2) the heliometer observations of Victoria made in 1889 on Gill's plan, and reduced by him. It was found that the observations of the Sun made after 1864 gave, by comparison with the published ephemerides, inadmissible corrections to the coefficients ; thus giving rise to the suspicion that in interpolating the places of the Sun, during at least some years after 1864, the inequality in question was rounded off to the extent of several hundredths of a second. The results were therefore omitted. The value of this coefficient, adopted in the solar tables, is 6″·454.

The elements and constants thus determined by Professor Newcomb are used in the construction of his tables of the Sun, tables of *Mercury*, and tables of *Venus*. The periodic perturbations of longitude and radius vector are deduced from those given in vol. iii. part 5 of the series of papers ; those of latitude are derived from the data of Le Verrier's tables. The perturbations given in vol. iii. part 5 were computed by adopting the development of the disturbing forces by means of the tables and formulæ of part 1 of the same volume. The perturbations themselves were then derived by a method substantially identical with that employed by Professor Newcomb in his theory of *Uranus*, published in 1873, in which the perturbations of the radius vector are first obtained. The tabulated quantities are the perturbations of the co-ordinates —a course preferable, in Professor Newcomb's view, to the tabulation of the perturbations of the mean anomaly, as in Hansen's method. The development of the perturbative function, as given in vol. iii. part 1, is a modification of Hansen's, and consists essentially of the analytic formulæ by which the development in terms of the eccentric anomaly is symbolically expressed as a function of the elements of the two planets. The transformation from eccentric to mean anomaly is then effected by means of the Besselian functions. It may be mentioned that in the course of this portion of the work Le Verrier's results were reduced so as to depend upon the mean anomalies, for the purpose of comparison. It was found that the agreement of the results was such as to place their accuracy beyond reasonable doubt.

The long period and secular terms of the perturbations are developed in vol. v. part 4 of the papers.

In the construction of the tables of the Sun, of *Mercury*, and of *Venus*, the arguments which are uniformly varying functions of the time are expressed so as to increase by a unit for each mean solar day. The fundamental argument, on which the elliptic terms and the perturbations depend, is the mean anomaly of the Earth, of *Mercury*, or of *Venus*, expressed in the same

unit. By an artifice familiar to those who are in the habit of using astronomical tables, one of the arguments in each table of double entry is made constant throughout an entire revolution. In fact, in all respects, so far as can be judged from an as yet necessarily imperfect acquaintance with the tables, they appear to have been constructed with great skill and care, so as to ensure ease and convenience in their application to actual computations.

Hill's theory of *Jupiter* and *Saturn* forms vol. iv. of the series of papers. This work was originally undertaken by Mr. Hill several years ago. The long interval which occurred between the publication of Le Verrier's theory of *Mars* and the appearance of anything from him on *Jupiter* and *Saturn* was the occasion of his first taking the matter up. As there was no desire to lose time by forming a special method of treatment, it was decided to employ the method of Hansen, with such slight modifications as might be suggested in the course of the work. The presence of the great inequalities renders this method a very suitable one for the purpose. It seemed necessary, however, to Mr. Hill to have a single independent variable for the whole work, in place of the two independent variables, one for the co-ordinates of *Jupiter*, and another for those of *Saturn*, which would be necessary if Hansen's use of the eccentric anomaly were adhered to. Therefore, the final form adopted for all the periodic series involved in the development of the disturbing forces was in terms of the mean anomalies, so that the time is always the independent variable. Only slight changes were necessary in Hansen's formulæ to render them applicable to this modification. For comparison with Le Verrier, in a few particulars, Mr. Hill has reduced Le Verrier's algebraically-determined coefficient of the great inequality of *Saturn* to Hansen's form, and to Bessel's value of the mass of *Jupiter*, and the result comes out $36''\cdot95$ larger than the value obtained by Mr. Hill. In the case of *Jupiter*, although Le Verrier's coefficients correspond to the mass of *Saturn* $1/3529\cdot6$, whilst Hill's correspond to the mass $1/3501\cdot6$, still it is found, for the more important terms, that the former are quite as large as the latter. "This, perhaps, explains why Le Verrier's discussion led him to the too small mass of *Saturn*."

The tables of *Jupiter* and of *Saturn* are founded on the theory thus developed; definitive elements being deduced in each case from the discussion of a long series of observations. The slight want of uniformity between the data of these tables and those of the four inner planets, to which reference has already been made, arises from the fact that it has not been possible to await the final determinations of the constants before proceeding with their construction. It should be noted, therefore, that in the tables of *Jupiter* and *Saturn* the longitudes are not referred rigorously to the adopted equinox, and that the masses of *Uranus* and *Neptune*, used in the construction of the tables, are not those finally adopted.

In the construction of the tables, the form so familiar to

astronomical computers who are accustomed to use Hansen's *Tables de la Lune* has been followed. Mr. Hill has, with much skill, introduced one or two devices for the purpose of increasing the accuracy of the results, or of lessening the labour of calculation, which computers will appreciate. As an instance, we may take the procedure adopted in tabulating certain of the perturbations of the mean anomaly and radius vector of *Jupiter*. In this case a difficulty is met with which arises from the decimal scale of notation. We have the choice between having a certain degree of accuracy or one ten times as great ; whereas the degree of accuracy desired lies midway between the two. Under these circumstances Mr. Hill tabulates, not the quantity finally required, but a quantity three times as great, which will merely add to the labour of the computer a single division to be performed on the sum of the perturbations thus multiplied. It will be remembered that a similar device was adopted by Le Verrier in his theories of *Jupiter* and *Saturn*, where the perturbations of double the semi-axis major are the quantities tabulated.

In his Presidential Address on presenting the Gold Medal to Professor Newcomb (*Monthly Notices*, vol. xxxiv. p. 227) Professor Cayley says : " I cannot help thinking that there should be some Confederation of Observatories, or Central Calculating Board, for publishing the lunar and planetary observations, &c., reduced to a concordant system. It seems hard upon the maker of a set of planetary tables that he should not at least have, ready to hand for comparison with his theory, a single and entire series of the observations of the planet." These words are as applicable to-day as they were twenty-two years ago, and come home with peculiar force to us when we consider the enormous amount of labour imposed upon Professor Newcomb in consequence of the existing diversity in the use of astronomical constants, places of fundamental stars, &c., as adopted at different observatories. Perhaps the publication of Professor Newcomb's work will do something to bring about a more satisfactory state of things. Meanwhile it will be the hope of all astronomers that Professor Newcomb will be able to continue his self-imposed labours, and bring to a successful conclusion his programme of the publication of a series of tables " intended to include the eight major planets of the solar system, and possibly the Moon and satellites."

A. M. W. D.

Star Catalogues.

The *Cape Catalogue* of 1713 stars for the equinox 1885·0, from observations made in the years 1879–1885, was published in 1894, but received too late for a notice of it to appear in the report of the Council last year. The stars observed are mainly fundamental stars and southern circumpolars. About 40 per cent. have ten or more observations. The clock stars employed

are those of the *Fundamental Catalog für die Zonen Beobachtungen am Nördlichen Himmel* between the limits $+10°$ and $-10°$ of declination. The right ascensions of clock stars were only included as determinations when at least five observations were made on the same night. A reversing eyepiece was used to eliminate any difference of personality for quick and slow-moving stars. About 500 stars in this Catalogue are contained in the Greenwich Ten-Year Catalogue for 1880. The differences of right ascension, Greenwich—Cape, expressed in equatorial time, are as follows :—

h h	s	h h	s
0–3	−0·011	12–15	+0·000
3–6	−0·016	15–18	−0·014
6–9	−0·014	18–21	−0·009
9–12	−0·010	21–24	−0·002

At the Cape there is practically no discordance between the reflexion and direct observations of zenith distance, but a horizontal flexure of $-0''·46$ was indicated by observations on the collimators from 1879–1885. This is the converse of what is found at Greenwich, where there is a considerable discordance between the reflexion and direct observations, but only a small (not more than $0''·2$) horizontal flexure. In the formation of this Catalogue Dr. Gill decided to apply a correction of $-0''·46 \sin \zeta$ to the direct observations, and to disregard entirely the discordance between the direct and reflexion observations caused by the introduction of this correction, considering the reflexion observation as entirely responsible for the difference. Accordingly, direct observations only were used, a correction $-0''·46 \sin \zeta$ was applied to them, Bessel's refractions of the *Tabulæ Regiomontanæ* were used unaltered, and the latitude taken as $-33° 56' 3''·35$. From a comparison of the Greenwich circumpolars, the Cape circumpolars, and the Greenwich and Cape observations of the same stars, Dr. Gill deduces corrections to the colatitudes and the refractions. From these are deduced corrections applicable to the Greenwich Ten-Year Catalogue and to the Cape Catalogue, the corrections to the latter being given definitively in a table at the end of the introduction. Since the Cape Catalogue was published M. Nyrén has published a Catalogue of fundamental declinations, and if weight is to be attached to the close agreement between this and the Ten-Year Catalogue, it would seem that the corrections to the Cape Catalogue should be increased. The following table is a rough comparison of the Cape Catalogue with M. Nyrén's, given along with Dr. Gill's comparison of the Ten-Year and the Cape :—

Mean N.P.D.	Nyrén—Cape.	Greenwich—Cape.
° ′	″	″
47·30	+0·55	+0·73
52·30	+0·39	+0·16
57·30	+0·09	−0·09
62·30	+0·06	−0·01
67·30	+0·15	+0·24
72·30	+0·11	+0·04
77·30	+0·12	+0·20
82·30	+0·46	+0·37
87·30	+0·27	+0·07
92·30	+0·39	+0·20
97·30	+0·24	+0·31
102·30	+0·25	+0·56
107·30	+0·01	+0·43
112·30	+0·23	+0·57

Reference numbers are given for all the stars to the catalogues of Bradley or Lacaille, Piazzi and the British Association Catalogue, and to the Southern Catalogues. Declinations are used instead of North Polar Distances more commonly found in English Catalogues. No correction is applied for proper motion from the epoch of the observation to the epoch of the Catalogue. In an appendix is given a Catalogue of 104 circumpolar stars from observations extending from 1881–1888, and in a second appendix are given the daily results reduced to 1885·0 of meridian observations of β and α and α_2 *Centauri*.

Another zone (20°−25° N. Decl.) of the Catalogue of the *Astronomische Gesellschaft* has been published during the year. The observations were made at Berlin by Dr. Becker in the years 1879–83. The Catalogue is a large and valuable one, containing 9208 stars, with a mean number of observations of 2·7 per star. The mean error of a single observation, deduced from the observations themselves, is $\pm 0^s\cdot030$ and $\pm 0''\cdot44$, and comparisons with Romberg's and the Greenwich Ten-Year Catalogue give results not much larger. Comparisons are given with Struve's "Positiones Mediæ," the Pulkowa Catalogue of 1855, Yarnall's Catalogue, the Second Armagh Catalogue, the Glasgow Catalogues, Romberg's Catalogue, the Greenwich Ten-Year, and the second Munich Catalogue (Bauschinger). Of the 9208 stars, 605 have determinable proper motions, which are given in a table along with the authorities for them; 281 of these are newly determined by comparison of the Berlin places with those other Catalogues, the proper motion obtained from each Catalogue being given separately, along with the number of observations, and the difference of epoch from the Berlin Catalogue. A list

is also given of stars whose places appear to be considerably in error in the older Catalogues.

A Catalogue of declinations and proper motions of 54 stars for use in the determination of the variation of latitude at New York has been compiled by Dr. Davis from all available Catalogues. The places of the stars have been brought up to 1875·0, and in the deduction of the proper motions systematic corrections have been applied to the different Catalogues to reduce them to the system of the *Fundamental-Catalog* of the *Astronomische Gesellschaft.* Altogether, 130 Catalogues from Bradley to the present time have been used, and no time or trouble has been spared in the attempt to obtain the declinations of these stars as exactly as possible.

F. W. D.

Double Stars.

The work in connection with double stars does not appear to show any falling off. As in the Report of last year, it is here treated of under the two heads—observation and calculation.

Observation.—The measures published in the year 1895 are :—

Memoirs Royal Astronomical Society, vol. li.

(*a*) A set of measures of 100 well selected stars, made with a 6-inch refractor during the years 1892–94 by W. H. Maw.

(*b*) Measurements of 70 stars, made with an $8\frac{1}{4}$-inch refractor at the Temple Observatory, Rugby, 1890–95, by G. M. Seabroke.

Mesures Micrométriques d'étoiles doubles faites à St-Petersbourg et à Domkino.—A separate publication, forming the third series of measures published by Professor Glasenapp, of the St. Petersburg University. They include measures made in 1882–89 with a 4-inch refractor, in 1889 with a 6-inch, and in 1894 with a $9\frac{1}{2}$-inch refractor. Altogether there are about 600 stars measured. Naturally, the earlier measures are of wide pairs.

Astronomische Nachrichten 3300.—Measures of 54 double stars made at the Königliche Sternwarte zu Berlin, in the years 1892–3–4, by Professor Knorre, with a Wellmann double-image micrometer attached to a 9-inch refractor.

Ibid 3303.—A set of measures of southern doubles made in 1894 at Sydney, New South Wales, by Mr. Sellors, with a 11·5-inch refractor.

Monthly Notices, Royal Astronomical Society, 1895 March.

(*a*) Measures of 12 southern doubles made by Mr. John Tebbutt with an 8-inch refractor at Windsor, New South Wales.

(*b*) A list of 28 probably new southern doubles by Mr. R. T. Innes.

Bulletin Astronomique, 1895 July.—Measures of 256 double stars made at the Paris Observatory, in the years 1890–94, with a 12-inch refractor by M. Bigourdan. These embrace 150 Σ stars, 76 OΣ stars, and 30 others.

Astronomical Journal, 359.—Measures of 34 double stars made with the $15\frac{1}{2}$-inch refractor of the Washburn Observatory in 1895, by Dr. T. J. J. See.

Calculation.—An unusual number of orbits of binary stars has been published during the year ; they are, however, mostly re-determinations of previously known elements.

Star's Name.	Period (Years).	*a* ″	*e*	Reference.
β 989, κ Pegasi	11·4	0·42	·49	*A.N.* 3285
OΣ 535, δ Equulei	11·5	4·45	·14	*A.N.* 3290
ζ Sagittarii	18·9	0·67	·279	*A.J.* 355
β 101, 9 Argûs	22·0	0·65	·70	*A.N.* 3297
Σ 2084, ζ Herculis	35·0	1·43	·497	*A.J.* 357
β 151, β Delphini	27·7	0·67	·373	*A.J.* 357
Σ 2173	46·0	1·14	·20	*A.N.* 3311
Σ 1523, ξ Ursæ Maj.	60·0	2·51	·397	*A.N.* 3323
OΣ 285	76·7	0·40	·470	*A.J.* 356
Σ 3062	104·6	1·37	·450	*A.N.* 3292
Σ 1356, ω Leonis	116·2	0·88	·537	*A.N.* 3311
Σ 2729, 4 Aquarii	126·7	0·70	·543	*A.J.* 341
Σ 1879	146·9	0·92	·58	*M.N.* 1891 Nov.
γ Coronæ Australis	152·7	2·45	·420	*A.N.* 3327
Σ 1536, ι Leonis	178·6	2·48	·76	*M.N.* 1895 June
Σ 1216	174·7	0·64	·43	*A.N.* 3283
Σ 1670, γ Virginis	194·0	3·99	·897	*A.J.* 352
Σ 60, η Cassiopeiæ	195·8	8·21	·514	*A.J.* 355
Σ 1938, μ Boötis	219·4	1·27	·537	*A.N.* 3309

A.N. = *Astronomische Nachrichten.* *A.J.* = *Astronomical Journal.*

M.N. = *Monthly Notices*, R.A.S.

Besides the calculation of orbits the work done includes the following :—

Astronomische Nachrichten, 3313.—Mr. Roberts investigates the mass, proper motion, and position of *α Centauri* from the Cape meridian observations.

The Observatory, 1895 February.—Mr. Lewis has a note on the motion of Σ 1306, *σ Ursæ Maj.* He shows that the motion is rectilinear.

The Observatory, 1895 March.—Mr. Lewis investigates the motion of the three stars forming the group Σ 1516.

Contributions from the Observatory of Columbia College, No. 6.—Professor Hermann Davis determines the parallax of the binary star Σ 60, *η Cassiopeiæ* from Rutherfurd photographic plates, $\pi = + 0''\cdot443 \pm 0''\cdot043$. T. L.

Schur's Heliometric Triangulation of Præsepe.

The fourth part of the Göttingen Observatory publications is devoted to measures of position of the brighter stars in the cluster *Præsepe* ; and principally to a heliometric triangulation of forty-five stars carried out during the years 1889 to 1893. The Göttingen heliometer (6-inch aperture, by Repsold) was erected in 1888 ; and after being adjusted was immediately devoted by Dr. Schur, the Director of the Observatory, to a piece of work projected twenty years before. On the occasion of the transit of *Venus* in 1874, Dr. Schur had resolved that if ever he possessed a fine heliometer he would undertake the triangulation of *Præsepe* at once ; and this resolution remained unshaken by the advances made in photography. The number of distances measured between different pairs of the 45 stars selected was 123 ; and the resulting equations are reduced to 74 normal equations with 74 unknowns. After some consideration a direct solution of these equations was undertaken, and completed after ten weeks' incessant labour. More than half a million figures were required, and the author justly claims that this piece of work ranks among the most laborious of the kind ever accomplished. The result, as shown by the residuals, is eminently satisfactory. But a study of the systematic errors leads to a new arrangement of the material, giving 68 normal equations with 68 unknowns ; and this new task was also undertaken and completed ; and the places for these 45 stars are thus obtained with great accuracy for epoch 1890.

Some thirty years before, Dr. F. A. T. Winnecke had made a careful series of measures of these 45 stars with the micrometer of the Bonn heliometer, though the observations were never completely reduced. The reduction is carried out by Dr. Schur in the second part of the volume just published, with every attention to the systematic errors. And, finally, in the third part of the volume, the two series of places are compared, and proper motions during the thirty years' interval are deduced, which must be of great accuracy, considering the immense care and labour bestowed upon both sets of observations. While most of the stars seem to have sensibly the same proper motion, there are six exceptions, which apparently do not belong to the cluster. It will be remembered that Dr. Elkin found similar outstanding stars in the case of the Pleiades.

The Astrographic Chart.

The *troisième fascicule* of the second volume of the *Bulletin* appeared under date 1895 March. In it M. Tisserand gives a general review of the situation in a preface, and, at the suggestion of Dr. Gill, proposes a meeting of the Committee in 1896 May. This meeting has now been definitely fixed for May 11 and succeeding days ; and it is hoped that several questions of great importance may then be settled.

The general situation, as reviewed by M. Tisserand and as given in detail in an appendix to the *fascicule*, is not much changed since last year's report of the Council. The completion of the catalogue plates may be counted on at an early date ; for instance, at the Cape Observatory all but fifteen have been obtained. The chart plates are, however, much behind, and at some observatories have not even been commenced. No reproductions of the plates have been published, though the Astronomer Royal has exhibited some specimens to this Society.

As regards the measurement of the plates, differences in methods adopted at different observatories will doubtless form a subject of discussion at the next meeting of the Committee, and comment may thus be profitably deferred until the next report. At Greenwich and Oxford the rectilinear method of reduction has been given a thorough trial, with satisfactory results. At Paris it is preferred to work with R.A. and Decl. throughout.

In an interesting paper M. Trépied discusses photographic magnitudes obtained from star-images, and comes to the conclusion that a test-plate must be taken on each evening and used in the reduction of the measures. He does not, however, consider the question how far the conditions change during the same evening.

Astronomical Photography.

The progress of astronomical photography during the past year has been marked by the improvement and increased use of appliances and modes of working already known, rather than by the production of any very novel features. Amongst the chief new instruments brought into use are the " Oblique Cassegrain " telescope of Dr. Common, and the Cassegrain reflector of 250 feet focal length, constructed by Professor J. M. Schaeberle, at the Lick Observatory. For this latter instrument Professor Schaeberle employed a silvered-glass mirror 18 inches in diameter and 12 feet focal length, which he constructed some years ago, and which it had been intended to mount as a Newtonian. This mirror Professor Schaeberle perforated and fitted up with a convex mirror on the Cassegrain system, and, after experimenting on mirrors of different convexities, finally adopted one giving

an equivalent focal length of 250 feet. With this telescope some very successful photographs of *Saturn* have been obtained, the diameter of the outer ring being 0·6 inches. The instrument is especially intended for planetary photography. At the Observatory of Yale College, also, a multiple camera for obtaining photographic records of meteors has been erected, this consisting of a massive equatorial mounting of the English type carrying six photographic cameras, these cameras being capable of collectively covering a large area of sky.

The value of photographic records in connection with variable star observations has been shown by the discovery of a large number of variables resulting from the examination, at Harvard College Observatory, of the photographs of stellar spectra made in connection with the work of the Henry Draper Memorial, and of the Harvard chart plates. The success in the photography of nebulæ and star groups obtained by Professor Barnard with the projecting lens of a small optical lantern, this lens being but $1\frac{1}{2}$ inch in diameter and about $4\frac{1}{2}$ inches in focal length, has shown how much can be done in competent hands by very moderate optical appliances. Dr. Sheldon has also been successfully working in the same direction, while Mr. Joseph Lunt has obtained some very satisfactory photographs with an equatorial telescope without clockwork, and guided entirely by hand, exposures up to 30 minutes being given. Dr. Roberts's photographic work during the past year is detailed as usual in the report of his Observatory.

An important contribution to the literature of astronomical photography has been made during the past year by Professor W. H. Pickering. This memoir, entitled *Investigations in Astronomical Photography*, forms Part I., vol. xxxii. of the "Annals" of the Harvard College Observatory, and deals with the photographic work carried out under the direction of the author at above-named observatory during the years 1887–1891. Treating first of fundamental principles, Professor Pickering discusses in detail the effects of variations in aperture and focal length of the telescopes employed, and describes modes of enlargement of the negatives, their reproduction on paper, the qualities of plates, methods of development, and other matters relating to the practical work of astronomical photography. A second section deals with the great nebula of *Orion* and results deduced from various photographs made of it, while a third section is devoted to the discussion of visual and photographic observations of the lunar surface. As regards telescopes, Professor Pickering expresses a preference for refractors in all cases where photographs have to be made for purposes of measurement; while he regards a reflector of long focus as especially suitable for photographing very faint stars, and a reflector of short focus as particularly adapted for dealing with nebulæ. Professor Pickering's experience favours the use of an enlarging lens in cases where planets or close double stars have to be photographed, an ordinary

positive eye-piece being, on the whole, found the best form of such lens. At Harvard Observatory the diameter in declination of the smallest star-images under the most favourable circumstances is 1″·5 when no enlarging lens is used, while with an enlarging lens discs as small as 0″·5 have been obtained, and images 0″·7 in diameter are frequently secured under good conditions.

The question of how astronomical photographs can best be copied for distribution is one of rapidly growing importance, and much remains to be done before it can be regarded as satisfactorily solved. Up to the present transparencies on glass have proved the most faithful reproductions, but these are inconvenient for transport and are open to other objections. Paper prints are, of course, by far the most convenient form of copies, and for popular illustrations of celestial features they serve perfectly. In a recent paper, Professor H. H. Turner (see *Monthly Notices*, p. 26, ante) has shown how paper prints may also be employed in cases where accurate measurements of stellar positions have to be made. When produced carefully, and by suitable processes, paper prints of astronomical photographs can undoubtedly be usefully employed for other branches of research, but all prints so used should be subjected to very careful comparison with the originals from which they are made. This is particularly the case with prints from photographs of comets or nebulæ, in which many appearances of false nebulosity may be caused by defective printing. Processes in which the image is developed on the paper —as in the platinotype process—are perhaps more liable to defects of this kind than "printing out" processes, but in any case very great care and experience on the part of the operator are necessary to ensure satisfactory and trustworthy results.

One of the most important features connected with the development of astronomical photography is the facility it affords for obtaining increased assistance in the carrying out of various lines of research. There are at the present time large numbers of more or less skilled astronomers, both professional and amateur, who are prevented from carrying out work of real scientific value owing to the want of proper instrumental means or other causes. By the proper utilisation, however, of astronomical photographs the abilities of this army of workers can be turned to account. Already the authorities of the Lick Observatory have offered to place copies of their lunar photographs at the disposal of those who will undertake to systematically examine them and discuss the features they record, while more recently Professor E. C. Pickering has similarly offered to supply copies of the Harvard photographs to those who will properly use them for variable star investigations. Dr. Roberts, too, has shown how useful work can be done by comparing the more recent photographs of nebulæ and those taken some six or seven years ago. To fully utilise the data recorded in the enormous store of astronomical photographs now being accumulated at

public and private observatories in all parts of the world some more organised system of examination than at present exists appears to be eminently desirable. It is not sufficient that the photographs of a particular class taken at one Observatory should be compared *inter se*: they should be compared also with other photographs of a similar class taken at other observatories with different instruments, and probably also with different plates and using different methods of development. It is only in this way that errors due to imperfections in the photographic processes can be properly eliminated, while such a comparison, if performed by competent examiners, and the results reported to the observatories supplying the photographs examined, would undoubtedly do much to improve future photographic work.

It was with a view of promoting the proper utilisation of astronomical photographs that the Royal Astronomical Society a year ago decided upon the publication of copies of photographs in their possession in a form which would render them available for the use of the Fellows at a moderate cost. During the current session a start has been made with such publication, and already copies of thirty photographs are available for issue in the form of prints (made by two processes—aristotype and platinotype) or as lantern slides. The demand which has arisen for the copies so published encourages the Council to believe that it will be possible to very greatly increase the number of photographs of which copies may be made available. Such extension of the scheme of publication must, however, necessarily be gradual, in the first place because the funds available for such work are limited, and secondly, because it is evidently undesirable to accumulate a stock of photographs for which there is no demand, a result which can only be avoided by experience of the requirements of the Fellows. It is hoped that as this experience is acquired, and as the work which the Society is doing in this direction becomes better known, it may be possible to publish extensive series of astronomical photographs, collated from a great variety of sources, bearing upon definite lines of research, and that in this way there may be rendered available for thorough scientific examination and discussion an enormous mass of data which is at present almost entirely unutilised.

The Astrophysical Journal.

A step which promises to be one of great importance for the development of the astrophysical side of astronomy was taken a little over a year ago, in the starting of *The Astrophysical Journal: an International Review of Spectroscopy and Astronomical Physics.* Professor G. E. Hale and other leading American astronomers had long been contemplating the desirability of devoting an entire journal to astrophysics, and so supplying one single standard means of publication for all papers bearing upon

the subjects embraced under that head, whether they approach them from the astronomical or the physical side. A beginning had been made three years earlier by the transformation of the *Sidereal Messenger* into *Astronomy and Astrophysics*, the last-named journal being divided into two distinct sections under separate boards of editors : the section of general astronomy and that of astrophysics. But having consulted many of the leading European astronomers, and having been assured of their co-operation and support, Professor Hale and his coadjutors found they were now able to give that international character to their undertaking which was essential to its full success. They therefore in 1895 January brought out the first number of a journal under the above title, and devoted entirely to astrophysical subjects, using that description to include almost all astronomical matters outside the domain of celestial mechanics and the measures of the positions of the heavenly bodies.

The editorial board is an exceedingly strong one. Professors Hale and Keeler are assisted, as in the direction of *Astronomy and Astrophysics*, by Professors Ames, Campbell, Crew, Frost, and Wadsworth. But in addition to these, France, Sweden, England, Italy and Germany are severally represented by the associate editors, MM. Cornu and Dunér, Dr. Huggins, and Professors Tacchini and Vogel. Whilst in America, Professors Hastings, Michelson, E. C. Pickering, Rowland and Young have also consented to act in a similar capacity.

The importance and high technical value of many of the articles which have appeared in the *Astrophysical Journal* during its first year of publication are a sufficient justification of its origination. A yet further value is given to it by the results of the first annual meeting of its editorial board At this meeting, held 1894 November 2, a circular was drawn up and sent to all the absent members of the board, asking their opinion on a number of questions. At the second annual meeting, held on 1895 October 17, votes having been received from all the members, the following standards were adopted.

1. The Rowland scale of wave-lengths as represented by the wave-length tables now being published in the *Astrophysical Journal.*

2. The "tenth metre," or ten-millionth of a millimetre, as the unit in which wave-lengths should be expressed.

3. The kilometre, as the unit to be used in measurements of motion in the line of sight.

4. The nomenclature proposed by Huggins and Vogel for the hydrogen series, in which the lines are designated Hα, Hβ, Hγ, &c., beginning at the red end, and continuing through the entire series.

5. Maps of spectra to be printed with the red end on the right.

6. Tables of wave-lengths to be printed with the shorter wave-lengths at the top.

All the editors favoured the use of these standards, not only in the *Astrophysical Journal*, but also in all other publications of a similar character; and it is to be hoped and expected that the decisions of so powerful a board, and one so international in its character, will be followed by all interested in astrophysical fields of work.

A useful feature of the *Journal* is the bibliography of recent astrophysical literature which is supplied in it month by month.

The Variation of Latitude, and the Constant of Nutation.

Under date 1895 June Dr. Foerster, of Berlin, published a memorandum suggesting that observations for following the variations of latitude should be undertaken at four observatories in the same latitude, viz. :—

Licata in Sicily,	long.	14° E.
Shirakawa in Japan	„	140° „
Felton in California	„	238° „
Petersburg in Virginia	„	283° „

He further suggested that this work should be undertaken by the Geodetic Association, and accordingly his proposals were considered at the October Conference. A new international Geodetic Convention was drawn up, involving increased annual contributions from the nations joining it, in order that this work on the variation of latitude might be undertaken. The headquarters of the Central Bureau are in Berlin; the Conference is to meet at least once in three years; and the expenses are estimated at 3,000*l.* a year for the next ten years; towards which the contribution of England (determined by its population), if it joined the Convention, would be 300*l.* a year. The reasons for this new departure are embodied in a "Notice justificative"; and the following extracts from this notice (kindly sent to the Council by Professor Foerster, in reply to a request by the Secretary) will explain the importance of this new departure :—

"Notice justificative sur l'Augmentation du Budget annuel de l'Association géodésique internationale.

"Les nombreuses observations de latitude que, dans le courant des six dernières années, l'Association géodésique a soit provoquées et appuyées, soit organisées directement, ainsi que les travaux analogues exécutés dans plusieurs observatoires, ont fourni la preuve évidente de variations sensibles dans la position de l'axe terrestre.

"Les variations constatées jusqu'à présent sont, il est vrai, assez faibles; toutefois elles dépassent sensiblement l'incertitude

avec laquelle la géodésie actuelle détermine les coordonnées géographiques.

"S'il était démontré que ces variations sont rigoureusement périodiques, de sorte que le pôle décrirait une courbe fermée, on pourrait, au moyen d'une série d'observations étendues sur quelques années, en déterminer la période et l'amplitude, et corriger les positions géographiques en raison de ces mouvements de l'axe terrestre.

"Mais, ni les observations, ni une des théories imaginées pour en rendre compte et pour expliquer ces phénomènes, ne donnent jusqu'à présent cette certitude. Au contraire, le travail d'ensemble que le Bureau central a fait exécuter par M. le professeur Albrecht sur les variations de latitude connues, et qui a été communiqué à la XI^me^ Conférence géodésique, conduit à envisager ces changements de l'axe terrestre comme un phénomène très compliqué, qu'on ne parvient pas à expliquer par une théorie simple, ni à représenter exactement par des formules de calcul, et dont les nombreuses séries d'observations des six ans ne suffisent pas à démontrer le caractère strictement périodique.

"Si à côté des variations à courtes périodes on devait reconnaître un mouvement de l'axe terrestre, progressif dans un certain sens, quelque faible qu'il fût, il résulterait, comme Helmholtz et Schiaparelli l'ont fait voir, d'un tel déplacement continuel de l'axe, des changements considérables dans la distribution des masses, non seulement du niveau des mers, mais aussi dans la configuration et l'arrangement des couches soi-disant fixes de l'écorce, mais qui sont probablement encore plastiques dans une certaine mesure, de sorte que ces modifications et le développement ultérieur des variations de l'axe devraient nécessairement être pris en considération dans les travaux pratiques de géodésie.

"En premier lieu, ce seraient les nivellements et les travaux hydrologiques, surtout les recherches importantes sur les phénomènes de marée à longue période, qui s'en ressentiraient.

"On peut donc affirmer que la continuation et le perfectionnement des mesures de variations de latitude, commencées sur une échelle plus grande à l'aide de l'organisation géodésique internationale, intéressent autant la géodésie que l'astronomie ou la physique du globe. Si l'on parvenait à montrer—ce qui ne serait en tout cas possible qu'en continuant les observations soigneusement et sur une vaste échelle—que les mouvements de l'axe terrestre ne s'éloignent pas, pendant un laps de temps de dix ans, sensiblement d'une forme purement périodique, dans ce cas seulement on serait justifié de prétendre que, dans l'intérêt purement géodésique, on pourrait interrompre ces recherches pendant un certain temps, tandis que les intérêts de l'astronomie et de la physique du globe exigeraient même alors la continuation régulière et générale de ces études.

"Pour pouvoir éclairer les incertitudes qui règnent encore sur

la nature et la forme future des changements de l'axe terrestre dont la première phase des recherches a démontré l'existence, il sera désormais indispensable d'organiser le plus tôt possible un système d'observations par lesquelles on pourra espérer d'arriver à la plus grande précision des mesures, en éliminant complètement l'influence considérable des mouvements propres des étoiles, que nous ne connaissons pas encore suffisamment pour en tenir compte dans ces recherches.

"Or, on ne peut réaliser cette condition d'une manière à la fois précise et simple qu'en organisant des observations simultanées de latitude au moyen de la méthode la plus exacte, dans plusieurs stations, réparties sur le même parallèle aussi également que possible, et dans lesquelles on emploierait les mêmes couples d'étoiles ; pour atteindre la plus parfaite simultanéité de ces observations, il importe de choisir le parallèle de façon que les conditions climatériques des différentes stations, surtout au point de vue de la clarté du ciel, soient les plus favorables. . . .

"Un argument important, qui vient encore s'ajouter à tous ceux dont il a été question jusqu'ici, est fourni par les perturbations systématiques de réfraction qui sont à craindre dans les salles d'observation, et sur lesquelles M. van de Sande Bakhuyzen et dernièrement l'Institut géodésique de Potsdam ont attiré l'attention des astronomes. Sous l'influence de certaines constructions des murs et des toits, comme on les rencontre dans la plupart des observatoires actuels, il peut se former des stratifications d'air de températures différentes qui, dans certains cas, sont assez durables et ont des gradients assez forts pour provoquer des perturbations dans la réfraction et rendre illusoires les conditions présumées pour l'emploi des meilleures méthodes qui servent à déterminer la hauteur du pôle.

"Les causes de ces perturbations sont bien plus difficiles à écarter avec les constructions compliquées de la plupart des grands observatoires, que lorsqu'on a affaire à de simples petites cabanes d'observation, qu'on peut placer en évitant autant que possible toute asymétrie affectant les températures dans les environs immédiats, et qui se réduisent à un simple abri pour l'unique instrument dont on a besoin dans ces observations ; de cette manière, les rayons des étoiles qui tombent sur l'objectif de la lunette parcourent un très petit chemin à travers le local d'observation et on peut s'affranchir de toute influence des températures des murs et des toits sur la marche des rayons.

"Ce seul argument suffirait pour réfuter l'opinion qu'il faudrait se contenter, pour les recherches en question, des moyens et des installations des observatoires existants. . . .

"Et encore ne faut-il pas oublier que—comme il a été prouvé plus haut—cette manière isolée et individuelle de procéder ne permettrait pas de décider sûrement, dans une dizaine d'années, l'importante question, si et dans quelle étendue il existe des

variations continuant dans le même sens pendant un certain temps.

"FOERSTER,

"Président de la XI^me^ Conférence générale de l'Association géodésique internationale et Membre de la Commission spéciale nommée par la Commission permanente pour l'étude des variations de la position de l'axe terrestre.

Berlin: Décembre 1895."

The discussion by Professor Albrecht of the observations on variation of latitude 1890–95 appears in the *Astronomische Nachrichten*, No. 3,333, published on 1896 February 8, and will thus more properly be alluded to in next year's Report. It deals with observations made at Kasan, Pulkowa, Prague, Berlin, Bamberg, Kiel, Karlsruhe, Strasburg, New York, Bethlehem, Vienna, Potsdam, &c. &c. ; and a diagram is given showing the motion of the north pole as a curve contained within a square of side 0″·60, but not a closed curve.

Dr. Chandler's work generally is referred to in the President's Address. During the year he has published one or two interesting notes on latitude variation, and an ephemeris for the years 1893–96 for the correction of meridian and other observations for these inequalities. Quite recently he has redetermined the constant of nutation from Greenwich mural circle observations during the years 1825–1848, after correction for variation of latitude, and finds the result 9″·192. Collecting previous results and weighting them, he obtains the definitive result 9″·202 for this constant, the corresponding reciprocal of the Moon's mass being 81·80 if 50″·36 is used for the lunar-solar precession. The Greenwich observations discussed relate to 36 fundamental stars distributed over the sky, and in a subsequent paper he discusses the declinations of these stars and compares them with Boss's system. The agreement is so satisfactory, and the discordance of the system of Auwers's *Fundamental-Catalog* so marked, that Dr. Chandler considers the time has now come when the latter must be given up as a standard, and recourse had to a system based on the observations of this century.

The Adams Memorial.

In the month of May in the past year the memorial medallion of the late Professor Adams was unveiled in Westminster Abbey. The simple words of the inscription—

JOHN COUCH ADAMS.

PLANETAM NEPTUNUM CALCULO MONSTRAVIT. MDCCCXLV.

record an achievement which made Englishmen wish to commemorate Adams by a memorial near to that of Newton.

There are many who look forward to the completion of another part of the memorial, namely, the publication in collected form of the papers of which many remained in MS. at the time of Professor Adams's death in 1892. It is therefore of interest to record that the first volume containing the already published papers is printed off and only awaits the introductory scientific memoir for publication; the second volume, which is to consist of researches and other matter communicated in lectures in the University of Cambridge, is being prepared by Professor R. A. Sampson, of Durham. We understand that Professor Sampson is well forward with the work, having completed the collation of several sets of MS. notes relating to the lectures on Lunar Theory and on *Jupiter's* satellites. The unpublished magnetic researches have been prepared for publication by Professor W. G. Adams, and are practically ready for publication.

The Universal or Zone-Time System.

During the year 1895 the Australian colonies have each adopted for general use a time-system which is based directly on the meridian of Greenwich. The Australian Continent, under this system, is not divided into zones bounded accurately by meridians 15° apart, as is the Continent of America, but the time-zones follow exactly the territorial divisions of the Continent. Thus the time in use in Western Australia is 8 hours, in South Australia 9 hours, in Victoria, New South Wales, Queensland, Tasmania, 10 hours fast on Greenwich time. This change was made in Queensland on 1895 June 1, and in the other colonies on 1895 February 1. Acts have been passed in the Parliaments of New South Wales, Victoria, South Australia, and Queensland, making the times as above described the legal time for these territories, but we have no information of similar Acts applying to the other colonies.

An Act (Definition of Time Act, 1895) has been passed in the Legislative Assembly of the Province of Ontario, making legal the standard time which has been in use in Ontario, as part of the zone-time system adopted over the whole of North America, for several years past. This is believed to be the first legislation on the subject in North America, and will probably be followed by similar enactments for other territories. The wording of the Act runs—"As regards that part of the province which lies east of the meridian of 87° west longitude, standard time shall be reckoned as 5 hours behind Greenwich time, and as regards that part of the province which lies west of the said meridian, standard time shall be reckoned as 6 hours behind Greenwich time."

A section of the Act reads—"The hours of the day may in any locality be numbered in one series up to 24, according to the '24-hour notation' so called, and the numbers so used shall be equally valid with the numbers used in the division of the day into two series of 12 hours distinguished as A.M. and P.M."

There is no information to hand that the Bill which is before the Austrian Parliament for the adoption of Central European time in Austria is yet passed.

H. P. H.

New Observatories.

No new observatories have actually been made since the date of the last Report, but the foundation of one such institution has been determined on, and it has been lately announced that two others are in process of erection. The first of these, and the one which promises to be the most important, as being the State observatory of a colony likely to grow in resources, is to be at Perth, Western Australia. The Government of this colony has voted a sufficient sum of money to provide a good Astronomical Observatory, containing a transit-circle and a photographic equatorial, and a residence for the astronomer in charge.

Sir John Forrest, the Premier of the Colony, consulted Sir Charles Todd, who prepared detailed specifications for the two instruments above-mentioned. The transit-circle is to have an object-glass of 6 inches in diameter, and circles (there are to be two, as the instrument is to be reversible) of 30 inches diameter. The astrographic equatorial is to have a 13-inch photo-telescope and a 10-inch visual telescope driven by electrically controlled clockwork. These instruments are now being made, the transit-circle by Messrs. Troughton & Simms, the equatorial and dome by Sir Howard Grubb, under the superintendence of the Astronomer Royal, who has consented to help the Colonial Government with his advice in this matter.

Mr. W. Ernest Cooke, M.A., who has been assistant to Sir Charles Todd at the Adelaide Observatory since 1882, has been appointed to the directorship of this Observatory.

The other two projected institutions are for educational purposes. One, called the Flower Observatory, is being erected by the University of Pennsylvania, on a site five miles west of the present University buildings and two miles beyond the city limits. This Observatory is to furnish facilities for instruction in astronomy and for research. Professor C. L. Doolittle is to have charge of this Observatory, and will have in his care an 18-inch equatorial with spectroscope, a meridian circle and a zenith telescope, each of 4 inches aperture.

The University of Minnesota, Maine, U.S.A., is also having an observatory set up for similar purposes. The principal instrument at present is said to be an equatorial of 10 inches aperture, with an additional lens for photography, and provided with a spectroscope and a photograph micrometer as accessories. Professor Leavenworth, of Haverford College Observatory, is to have charge of this observatory.

H. P. H.

Papers read before the Society from March 1895 to January 1896.

1895.

Mar. 8. Ephemeris of the five inner satellites of *Saturn*, 1895 A. Marth.

Filar micrometer measures of the diameters of the four bright satellites of *Jupiter*, made with the 36-inch equatorial of the Lick Observatory. E. E. Barnard.

The transit of *Mercury*, 1894 November 10. W. F. Gale.

A list of probably new double stars. R. T. A. Innes.

The transit of *Mercury*, 1894 November 10, observed in Queensland. J. P. Thomson.

Micrometrical measures of the ball and ring system of the planet *Saturn*, and measures of his satellite *Titan*, made with the 36 inch equatorial of the Lick Observatory. E. E. Barnard.

Double star measures, 1892–94. W. H. Maw.

Results of double star measures with the 8-inch equatorial at Windsor, New South Wales, in 1894. J. Tebbutt.

Notes on the variable stars X and W *Sagittarii*. Lieutenant-Colonel E. E. Markwick.

Note on a suggested form of equatorial mounting for a (modified) Newtonian reflector. Rev. C. D. P. Davies.

On the proper motion of the star *Cephei* 24 (Hev.). W. T. Lynn.

On the proper motion of the star *B.A.C.* 793. W. T. Lynn.

The Wilsonian theory and the Stonyhurst drawings of Sun-spots. Rev. W. Sidgreaves.

Observations of Encke's Comet made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

An apparatus for mechanically calculating star corrections. W. E. Cooke.

Note on the above paper. H. H. Turner.

A negative optical proof of the absence of seas in *Mars*. H. Dennis Taylor.

A systematic comparison between the places of stars given in the Cape Catalogue for 1880 and the Radcliffe Catalogue for 1890. E. J. Stone.

Mar. 8. On the mean places of eight southern close polar stars. E. J. Stone.

Observations of the vertical diameter of the planet *Jupiter*. T. J. Moore.

Apr. 10. Equatorial comparisons of *Jupiter* and 1 *Geminorum*. John Tebbutt.

On a modified form of Cassegrain telescope. W. R. Brooks.

Note on the total eclipse of the Moon, 1895 March 10. H. F. Newall.

Note on η *Cassiopeiæ*. T. Lewis.

Occultation of *Antares*, 1894 October 31. R. T. A. Innes.

The Brachy telescope of Messrs. Fritsch and Forster of Vienna. A. A. Common.

Observations of occultations of stars during the lunar eclipse of 1895 March 10, made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

The total eclipse of the Moon, 1895 March 10. G. J. Newbegin.

The solar eclipse of 1895 March 25. G. J. Newbegin.

Pallas and *Vesta* in 1895. W. W. Bryant.

Observation of the partial eclipse of 1895 March 25, at the Armagh Observatory. J. L. E. Dreyer.

Observations of Occultations of stars during the total eclipse of the Moon on 1895 March 10, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Notes on the observations for coincidence of the collimators in flexure determinations with the Greenwich transit-circle, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

May 10. Occultations observed at Harrow during the total eclipse of the Moon, 1895 March 10. Lieutenant-Colonel G. L. Tupman.

Partial eclipse of the Sun, 1895 March 25. A. A. Rambaut.

On the variable nebula of Hind and Struve in *Taurus*, and on the nebulous condition of the star *T Tauri*. E. E. Barnard.

On the rotation of *Saturn* in 1894. A. Stanley Williams.

Observations of minor planets made at the Observatory, Tacubaya, Mexico. F. Valle.

The thermal radiation from Sun-spots : Observations made at Daramona, Streete, Co. Westmeath. W. E. Wilson.

On a fixed system of star co-ordinates (abstract). R. H. M. Bosanquet.

Photograph of the nebula near 15 *Monocerotis*. Isaac Roberts.

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May 10. Photograph of the Crab Nebula M 1 *Tauri*. Isaac Roberts.

Observations of the phenomena of *Jupiter's* satellites, and of the transits of the red spot, dark and bright spots, &c., made at Bermerside Observatory, Halifax, during the winter of 1894–95. J. Gledhill.

Answer to an inquiry in the *Bulletin Astronomique* for 1895 May. E. J. Stone.

Micrometer measurements of *Phobos*, the inner satellite of *Mars*, during the opposition of 1894. H. F. Newall.

June 14. On a photographic study of the Earth-lit portion of the new Moon. E. E. Barnard.

On a great photographic nebula in *Scorpio* near *Antares*. E. E. Barnard.

Note on the proper motion of *Arcturus*. W. T. Lynn.

Observations of *Jupiter*. W. F. Denning.

The relation between precession and proper motion. R. H. M. Bosanquet.

A general method for facilitating the solution of Kepler's equation by mechanical means. T. J. J. See.

On the accuracy of late catalogues of declinations of standard stars. T. H. Safford.

Ephemeris for physical observations of *Jupiter*, 1895–96. A. Marth.

On a catalogue of stars in the Calendarium of Mohammad Al Achsasi Al Mouakket. E. B. Knobel.

Diameters of *Jupiter* and satellites observed at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

A determination of the mean N.P.D., 1790 January 0, of γ *Draconis* from observations made at Oxford by Dr. Hornsby. E. J. Stone.

Meridian observations of *Sirius* and *Procyon* at the Royal Observatory, Greenwich, 1836–94. W. G. Thackeray.

Note on the binary star ι *Leonis*. Alice Everett.

Further measures of double stars made at the Temple Observatory, Rugby, by G. M. Seabroke and H. P. Highton.

On the angular distance of two stars in the *Pleiades* suitable for determining the value of a micrometer screw. H. H. Turner.

Nov. 8. Results of micrometer comparisons of *Saturn* and κ *Virginis*. John Tebbutt.

Observations of phenomena of *Jupiter's* satellites with the 8-inch equatorial at Windsor, New South Wales, in the year 1895. John Tebbutt.

Nov. 8. Comparisons of the Sun's longitudes for 1900, computed from Newcomb's tables of the Sun, with those computed from Le Verrier's tables. A. M. W. Downing.

Description of a mechanical apparatus for computing refractions. W. E. Cooke.

Micrometrical determinations of the diameters of the minor planets, *Ceres* (1), *Pallas* (2), *Juno* (3), and *Vesta* (4), made with the 36-inch equatorial of the Lick Observatory, and on the albedos of these planets. E. E. Barnard.

Ephemeris for physical observations of *Jupiter*, 1895–96 (concluded). A. Marth.

On the extended nebulosity about 15 *Monocerotis*. E. E. Barnard.

Data for computing the positions of the satellites of *Jupiter*, 1895–96. A. Marth.

Invisibility of Hind's variable nebula (N.G.C. 1555). E. E. Barnard.

Observations of Encke's Comet, 1894–95, made at the National Observatory, Tacubaya, Mexico. F. Valle.

Observations of minor planets made at the National Observatory, Tacubaya, Mexico. F. Valle.

Note on Hansen's lunar and planetary theories. E. W. Brown.

Results of filar micrometer comparisons of *Saturn* and 96 *Virginis*, and of *Ceres* with neighbouring stars. John Tebbutt.

Photograph of the nebula $\frac{h}{0}$ VI. 41, and a new nebula in *Draco*. Isaac Roberts.

Photograph of the cluster $\frac{h}{0}$ VIII. 76, and of a new nebula in *Cygnus*. Isaac Roberts.

Observations of the variable star *T Centauri*. Lieut.-Colonel E. E. Markwick.

Mean areas and heliographic latitudes of sun-spots, deduced from photographs taken at the Royal Observatory, Greenwich; at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

Diameters of *Saturn* and his rings observed during the opposition of 1895 at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on the discovery of the graphical method for solving Kepler's equation by means of a curve of sines. T. J. J. See.

Note on the value of the longitude in the lunar theory when the Sun's mass is put zero. P. H. Cowell.

The orbit of Σ 1879. T. Lewis.

Note on the measurement of paper prints of stellar photographs. H. H. Turner.

Dec. 13. The radiant point of the October meteors. W. F. Denning.

Dec. 13. Setting apparatus for a transit-circle. W. E. Cooke.
On the proper motion of Lacaille 4336. R. T. A. Innes.
On the proper motion of μ *Cassiopeiæ*. W. T. Lynn.
Photograph of the spiral nebula M. 33 *Trianguli*. Isaac Roberts.
Note on some remarks of M. O. Callandreau in the *Bulletin Astronomique* for 1895 November. E. J. Stone.
Note on a crayon drawing of the Moon by John Russell, R.A., at the Radcliffe Observatory, Oxford. E. J. Stone.
Observations of comets *Encke* 1894 and *Swift* 1895 August 20 made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.
Observations of Perrine's Comet (*c* 1895) made with the altazimuth at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
Observation of variable stars. The late George Knott.
Note on Newcomb's Tables of the Sun. A. M. W. Downing.

1896 Jan. 10. Details of the total solar eclipse of 1896 August 8–9 for Kushiro, in the island of Yezo. Communicated by the Superintendent of the *Nautical Almanac*.
Photograph of the *Owl* nebula M 97, and of the nebula H V. 46 *Ursæ Majoris*. Isaac Roberts.
Photograph of the cluster H VII. 66, and of the nebula H IV. 75 *Cephei*. Isaac Roberts.
Micrometrical measures of the ball and ring system of *Saturn*, and measures of the diameter of his satellite *Titan*, with some remarks on large and small telescopes. E. E. Barnard.
Observations of Comet *d* 1895 (Brooks) made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
Observations of occultations of stars by the Moon, and of the phenomena of *Jupiter's* satellites, made in the year 1895 at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.
Ephemeris for physical observations of the Moon 1896. A. Marth.
On the drift of the surface material of *Jupiter* in different latitudes. A. Stanley Williams.
On the determination of positions of stars for the Astrographic catalogue at the Royal Observatory, Greenwich. W. H. M. Christie and F. W. Dyson.
Expressions for the elliptic co-ordinates of a moving point to the seventh order of small quantities. E. J. Stone.

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ADDRESS

Delivered by the President, A. A. Common, LL.D., F.R.S., on presenting the Gold Medal to Mr. S. C. Chandler.

The Council have awarded the Gold Medal to our Associate, Mr. Seth C. Chandler, "for his discussion of the variation of latitude, his work on variable stars, and other astronomical investigations"; and I have now to state to the Society the considerations that prompted this award, which happily I can do by a very brief review of the work of our medallist.

Before doing this I must express my regret that this chair is not occupied by one more familiar with the class of work under review, by one who could have subjected it to that critical comment to which the President's address on this occasion is so often devoted, and which I am sure the work in question would so well bear. Such criticism of our medallist's work is perhaps less needed on this occasion, as it has already been subjected to the competent examination of three of our Associates who are also medallists (Newcomb, Gould, and Asaph Hall), who signed the report of the Watson Trustees to the American Academy of Science, when the Academy in 1894 awarded the Watson Medal to Mr. Chandler. The fact that my own work is on other lines does not preclude me from expressing the great pleasure it has been to read again more carefully, for the purpose of this address, the many papers containing Mr. Chandler's contributions to astronomy, and my admiration of his work, particularly of that laborious portion resulting in the discovery of the law of variation of latitude.

This question of the variation of latitude in its present aspect dates back only a very few years. It was first noticed in our Annual Report in 1891, but there is no note in the 1892 Report. By the date of our annual meeting in 1893, however, the chief discovery of our medallist (the variation in a period of 428 days) had been made, and eight or nine papers had already appeared of that brilliant series of researches by which the complete law of variation has been practically established. This series, including investigations arising from the main inquiry, has been continued to the present time; and the consequences of Mr. Chandler's discoveries are so far-reaching, and his energy in following them up is so unfailing, that we may hope for equally interesting

results in the future. But the work has already reached a stage of completeness in that the main investigation is concluded. Our medallist has sufficiently elucidated the law of latitude variation to publish an ephemeris of it. In his own words, "The relative motion of the earth's axis of figure and rotation is governed by a law, synthetically derived from observation, whose constants are so accurately known that we can with certainty compute in advance tables of the variations of latitude for any given station," and he proceeds to give such tables for the years 1893–96 for which "a convenient and suitable place in the future would be the various astronomical ephemerides." Remembering that the variation of latitude was not much more than suspected some five years ago, and that there was not even a suspicion of the true *law* of variation (except, perhaps, in the fertile brain of our medallist), the proposition to now print such tables of prediction side by side with tables of the planets is somewhat startling. But a careful examination of Mr. Chandler's work forces upon us the conviction that his confidence in it is justifiable. In the past four or five years he has found time to discuss, exhaustively for the present purpose, all the observations available from Bradley to the present time, so that as regards their foundation his ephemerides are well worthy of a place beside others; while the close accordance of results derived from such a large number of independent sources is a guarantee of the accuracy of the law finally adopted.

The history of these investigations is most interesting. More than a century ago it was shown by Euler that if the axis round which the Earth revolves be not coincident with the axis of figure, the position of the former in the earth would shortly change, revolving round the axis of figure in 305 days. Euler's work started with the assumption that the Earth was a perfectly rigid body, which is not the case, and we shall presently see how this assumption affects the result; but it never occurred to anyone until a year or two ago to consider the effect of non-rigidity. Euler's result was accepted, and search was made for indications of this motion of the axis of rotation in a period of 305 days, or ten months; but no such motion was found, though several investigators tried to detect it. The first to make the attempt, though unsuccessfully, was C. A. F. Peters, then at Pulkowa. Negative results were also obtained at Washington, at Pulkowa again by Nyrén, and by Clerk-Maxwell and Downing from Greenwich observations. It was thus supposed that the axes of rotation and figure were sensibly coincident, and little further interest was taken in the matter. The first fifty volumes of our *Monthly Notices* contain no reference to the variation of latitude beyond the paper by Downing, of two or three pages, in which he shows that ten years' Greenwich observations of *Polaris* show no 305 day variation.

The question was definitely reopened by Küstner, of Berlin. In 1885 he remarked that some curious discordances affecting

Nyrén's observations with the prime-vertical transit could be accounted for by supposing a change of latitude; and in 1888 he published a memoir on the constant of aberration, as deduced from a series of observations made by him at Berlin in 1884–5, from which it appeared incidentally that the latitude of the observatory must have changed during the period of observation. So conclusive was this demonstration of change that special attention was forthwith directed to the point by the International Geodetic Association. Under its auspices special observations were organised to detect any changes in latitude at three or four observatories, with immediate and conspicuous success. I cannot here follow the course of this observational work, which has proceeded continuously up to the present time, and which it is now proposed to extend and develop further. The investigations of our medallist have been conducted to a large extent independently of it (though latterly he has made excellent use of the valuable material resulting from these observations), and we are to-day concerned especially with his work alone.

As above stated, it was Dr. Küstner who first called the attention of the astronomical world to the variation of latitude; but similar ideas had occurred to Mr. Chandler at about the same time, though circumstances prevented him following them up. In the years 1884–5 he made a thirteen months' series of observations with the almucantar (an instrument of his own devising, of which I shall presently speak), which revealed a progressive change in the value for the latitude given by this instrument, and he was unable to refer this apparent change to anything instrumental. As he says later, he hesitated then to ascribe it to a real change of latitude without further investigation, which he was not able to undertake at the time. Six years later, when the change had been meanwhile strikingly confirmed by the publication of Küstner's observations (also in 1884–5), and general attention had been called to the matter, Mr. Chandler was able to resume the inquiry, and his success in finding the key to the solution of the problem was almost immediate. His work is detailed in some score of papers in the *Astronomical Journal*, following one another with marvellous rapidity, considering that the amount of work represented by each was in general undertaken and completed in the interval since the last. For when sure that he had got hold of the real thread, Mr. Chandler began to publish at once without waiting to unravel the tangle completely. As he cleared each successive length, he presented it to the world; and this method gives a freshness to the resulting series of papers which can only be realised by reading them in the original.

The first important step, the detection of the fourteen months period in the latitude, resulted from an examination of the Pulkowa vertical-circle observations, 1863–1875, and the Washington vertical-circle observations 1862–1867. This periodicity was confirmed by examination of observations at Melbourne and

Leyden at about the same time. Here was a singular discrepancy with Euler's theory ; which had so definitely indicated a period of ten months, if any, that none other had hitherto been looked for. An explanation of the apparent conflict between theory and observation was, however, soon given by Professor Newcomb, who pointed out that a deviation from absolute rigidity in the Earth would alter the Eulerian period. More elaborate investigations of this point have since been made by Woodward in America and Hough * in England, and there seems little doubt that this explanation, fortunately so quickly forthcoming, is the true one. But the few months during which theory and observation were not reconciled had a marked effect upon the future course of Mr. Chandler's work, which was from that time characterised by a stern resolution to set aside any teaching of adopted theories and to let the observations speak for themselves. I do not mean to suggest that this resolution was born after the beginning of his researches, for it can be traced in his first papers ; but it was undoubtedly much strengthened by the events of these few months, during which his results were regarded by many as very questionable, owing to their want of accordance with a theory afterwards shown to be defective. And his resolve stood him in good stead, for his deductions from observation were soon again at variance with theory. On examining earlier observations in Bradley's time he found that the fourteen months' period had disappeared, and in its place was a variation in twelve months of larger amplitude : and there were indications of a progressive change from one period to the other. These results, promptly and fearlessly announced, brought a new wave of scepticism, and almost carried back those who had been won over (like Professor Newcomb) into the opposition camp. Fixed in his determination, however, to be undismayed by any apparent conflict with theory, our medallist went on patiently examining huge masses of observations wherever he could find them suitable for his purpose. The situation is so dramatic and the study of it such an incentive to true scientific investigation that I make no apology for re-

* In a paper communicated to the Royal Society last month, Mr. Hough gives an analytical investigation of the motion of simple rotation about a principal axis, taking into account elastic distortions due to variations in centrifugal force ; the results are found to agree in the main with those obtained by Professor Newcomb from geometrical considerations. The analysis deals with the case of a homogeneous spheroid of revolution, the ellipticity being such that the body is free from strain when rotating uniformly. Such a spheroid, if of the same size and mean density of the earth and rotating with the same angular velocity, would oscillate in a period of 232 days if perfectly rigid ; it is shown that this period would be extended to 335 days in virtue of elastic distortions if the rigidity were equivalent to that of steel. In the case of the Earth the period would be still further prolonged in consequence of variations in density, and the period which corresponds to the above degree of rigidity is estimated at about 440 days ; whence it is concluded that the observed period may be accounted for by supposing that the Earth is capable of elastic deformation, and that its effective rigidity is slightly in excess of that of steel.

calling Mr. Chandler's own statement of it, which has already been quoted in the Report for 1893 :—

"It should first be said that in the beginning these investigations I deliberately put aside all teachings of theory, because it seemed to me high time that the facts should be examined by a purely inductive process; that the nugatory results of all attempts to detect the existence of the Eulerian period probably arose from a defect of the theory itself; and that the entangled condition of the whole subject required that it should be examined afresh by processes unfettered by any preconceived notions whatever. . . . The appeal to observation, treated irrespective of theory, in the present series of papers, shows that a rotation of the pole really exists, but (*a*) at a daily rate of but 0°·85 (for 1875), and (*b*) that this velocity is subject to a slow retardation, which, in its turn, is not uniform. . . . The result (*a*) was at first pronounced impossible, and is even now so regarded in some quarters. Professor Newcomb, however, soon after found the defect in the theory, and is now as cordially in favour of the result given by observation as he was originally against it. . . . Now, may it not reasonably be asked if the direct deduction from observation has led to the correction of theory in the first particular, is it beyond hope that it may do so in regard to the second?"

Six weeks after the publication of these words "theory and observation were again brought into complete accord," but this time by Mr. Chandler himself. By re-arranging his material he found that the variation of slowly changing period and amplitude which had scared away his theoretical friends was really a superposition of two variations, one in fourteen months and the other in twelve, one of which gradually overtakes the other in the familiar manner. He has gradually built up the complete description of this compound motion, and has shown that the former component is due to a circular revolution of the pole of the axis of figure about the pole of rotation in a radius of 14 feet: and the latter to the motion of the pole of figure in an ellipse 25 feet long and 8 feet broad, the major axis being inclined at present about 45° to the Greenwich meridian. There are indications of slow changes in these elements, and other details on which I need not here dwell. Rather would I call your attention to one or two general characteristics of Mr. Chandler's work, which stamp it as in every way worthy of the honour now conferred upon him.

I have already mentioned his determined independence of preconceived hypotheses, and his resolution to appeal to the facts themselves, and to them alone. An equally striking feature of his work is the enormous mass of it, of which it is difficult to give an adequate idea. The fact that in the last five years he has contributed fifty papers to the *Astronomical Journal*, covering in all 150 pages, is in itself noteworthy; but many of these papers represent in a few pages an amount of work which it is

almost impossible to estimate. Paper No. VI. of the series on variation of latitude, for instance, gives the results of the examination of forty-five different series of observations at different observatories. Three other papers of the above fifty are the Second Catalogue of Variable Stars and its two supplements; and a short note, of only half a page, announcing the recent discovery of a variable period of $5\frac{1}{2}$ hours, represents a large amount of work at the telescope. Throughout the absorbing researches on latitude Mr. Chandler never lost touch with variable stars and comets, on which he had laboured for many years; and I might emphasise not only the amount but the variety of his work. Yet I trust I may not appear fanciful in suggesting that in this variety of work there is a unifying principle, for it seems to me that Mr. Chandler's genius for the detection of a new period is manifest throughout. His work on variable stars led up to his great discovery in the variation of latitude. The two Catalogues of Variable Stars with their supplements, which he has published, are no mere compilations, but represent the critical scrutiny of all available observations; the correction of many elements and the revision of others; the detection of waves subsidiary to the main light-curve; and, finally, several actual discoveries by the author himself. Such work as this trained his natural delicacy of perception of periodicity, and he became an expert, thoroughly competent to deal with such problems. To detect an existing periodicity or to trace the true cause of abnormal observations may seem an easy matter to those who have not tried it, but history proves the contrary. Thirty-nine years ago our Medal was awarded to M. Schwabe for his discovery of the periodicity of solar spots. The occupant of this chair then cited several authorities to show that for a century previous to the commencement of Schwabe's work no suspicion of periodicity had been awakened—nay, more, that any systematic regularity in the appearance of sun-spots was categorically denied. Schwabe's discovery was only made as the result of thirty years' unremitting labour at the telescope, though it is difficult for us now to imagine how it could have been overlooked by the most casual observer, so different is the situation before and after the discovery. A minor instance of the difficulties attending the detection of a true period has recently been afforded by our medallist himself in the case of his new variable of $5\frac{1}{2}$ hours period.

"It may not be amiss to add," he says, "that I discovered the variability of this star more than a year ago, but erroneously inferred that it was of the Algol type, with a period of 2·06 or 2·07 days; a mistake due to the near commensurability of nine of the true periods with two solar days." Thus the star had run through its changes some 1,500 times while under careful scrutiny before its true period was detected. Most of the time it was, of course, not available for observation owing to daylight and cloud: and this necessary intermittence in the observations with the

masking of the period by commensurability with others, as above-mentioned, are two of the chief difficulties in such work. We have recently seen a remarkable illustration of these difficulties in the controversy respecting the rotation periods of *Mercury* and *Venus*. These planets can only be observed intermittently at intervals of about a day, and it is not yet established beyond question whether their rotation periods are commensurable with the mean solar day or with their periods of revolution round the Sun. It is difficult to imagine what would have been the case with that greatest of modern discoveries—the finding of *Neptune*—if a working hypothesis in the shape of the assumed elements indicated by Bode's law had not existed, or how long another important discovery, that of argon, and indirectly of helium, would have been postponed, if the anomalous observations of the weight of nitrogen had not been traced to their true cause by Lord Rayleigh.

So far I have spoken chiefly of Mr. Chandler's great discovery of the true law of variation of latitude; and this address has already run to such a length that his other work, sound and original as it is, must be reviewed very briefly. His Catalogues of Variable Stars, and his observations and discoveries in this department of science, have already been mentioned, and though much might be said in their praise, I must reluctantly forego this privilege on the present occasion. I would, however, claim your attention for a few moments to the instrument devised by Mr. Chandler, and called by him the almucantar, embodying as it does a new principle applied with great success to an observing instrument of precision.

A full account of this instrument, with the methods of using it and the observations made, extending over a period of thirteen months, forms Vol. XVII. of the *Annals of Harvard College Observatory*. It is the outcome of an idea which occurred to Mr. Chandler that another method of making that class of observation for which meridian instruments are used might be accomplished by substituting for the meridian as a fundamental plane of reference the small circle perpendicular to the meridian passing through the pole, and for the motion of rotation determined by the pivots of a horizontal axis, one determined by gravitational action round an imaginary vertical axis. Two ways suggested themselves of carrying out this object: to suspend the instrument like a pendulum, or to float it on mercury. Both were tried, but the latter plan, as involving fewer mechanical difficulties, was adopted for a small trial-instrument of $1\frac{3}{4}$-inch aperture and 25-inch focal length. With this instrument and method results of a surprising degree of accuracy were obtained—for instance, the latitude of the Harvard College Observatory as determined with it was eventually found to be more accurate than that determined by the fixed instruments of the observatory.

Of the larger instrument subsequently made, which forms the subject of the memoir already mentioned, it is not necessary

for me to say more than that the discussion of the observations made with it shows that it is a most valuable instrument, capable of an accuracy equal to, if not exceeding, that of larger fixed instruments.

One particular point I would like to mention is the marvellous accuracy with which the telescope comes to its true place after each fresh setting. As you no doubt are aware, the observing telescope, and the horizontal axis on which it moves in a vertical plane, are carried by a counterpoised float in a box of mercury, this box in its turn being supported on a vertical axis. The float with the telescope on it is quite free from mechanical connection with the box, the only restraint being that given by two pins working in upright guides to restrain movement sideways.

When the telescope is clamped on its axis to any altitude, the circle it would describe in the heavens if rotated on the vertical axis would be a small circle or almucantar; and the successful use of the instrument depends on the truth with which the telescope can be set to different points on the small circle to which it is at first pointed. Although between each setting the rotation in azimuth sets up a considerable amount of oscillation, the instrument settles down after a short time to a position so nearly the true one that it is difficult to determine its departure from it. In that part of the memoir speaking of this, Mr. Chandler says that after a couple of minutes a mean position of equilibrium is regained within a range of variation so minute that no means exist of measuring it with certainty. In Chap. V. it is experimentally demonstrated that the probable error of equilibrium must lie within one-tenth of a second of arc, corresponding to one hundred thousandth of an inch difference in the two ends of the float.

The consistent way in which this instrument behaves, and the remarkable accuracy with which it takes the true position after a change in azimuth, are due not only to the principle of floatation employed, but also to the peculiar simplicity of construction that this principle allows, for the fresh settings are obtained without the least change of strain in the instrument. In this latter respect it enjoys an advantage over the necessarily heavy meridian instrument with its puzzling flexure; the freedom from mechanical connection with the Earth gives it another hardly less important; while the cost of the respective instruments would be greatly in favour of the simpler form. It seems to me that we have in this instrument capabilities that have not yet been fully appreciated and applied.

It has often occurred to me how the personal character of the designer of an instrument is reflected in the design. We can certainly recognise the same independence of preconceived notions in the almucantar that Mr. Chandler shows in his theoretical discussions; and we find another point of similarity when we compare the speedy way in which the instrument in question takes up and keeps its true position after a few oscillations, with

the manner in which, after a few tentative hypotheses, none of them far from the truth, our medallist found and maintained the real solution of the problem of the variation of latitude.

In this brief review of your medallist's work I think I have said amply sufficient to show you that in computational, observational, and instrumental astronomy, our medallist is in the first rank, and is, indeed, well worthy of the highest honour which it is in our power to bestow upon him.

Dr. Huggins, I place this medal in your hands, as Foreign Secretary, for transmission to Mr. Chandler. Will you express to him our high appreciation of his contributions to astronomy, and our hope that he may be long spared to further enrich our science.

Our regret that Mr. Chandler is unable to be present to-day is tempered by the expectation that some of our Fellows in crossing America for the observation of the Solar Eclipse will be able to personally express this appreciation and hope in a warmer way than can well be done in a letter.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :

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